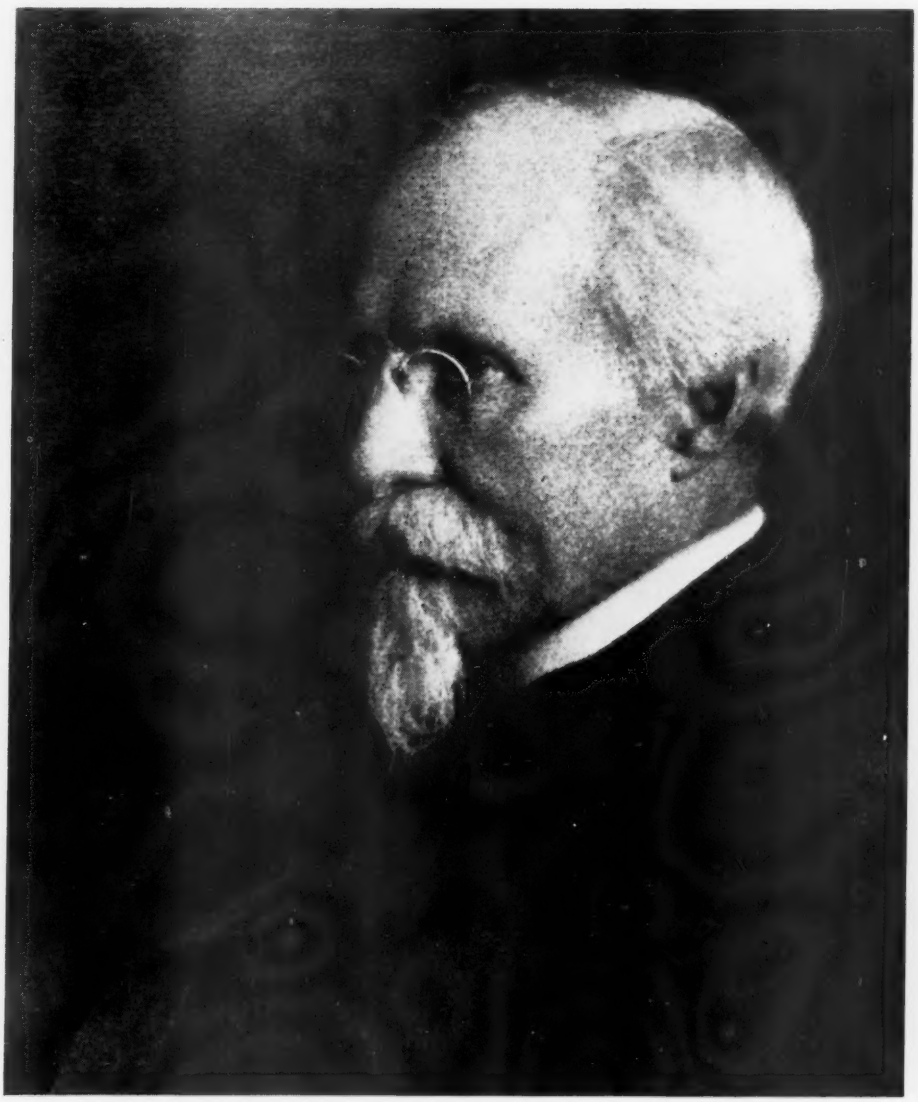
THE BULLETIN

OF THE

AMERICAN CERAMIC SOCIETY

Volume 20 AUGUST, 1941 Number 8



JOHN PITCAIRN

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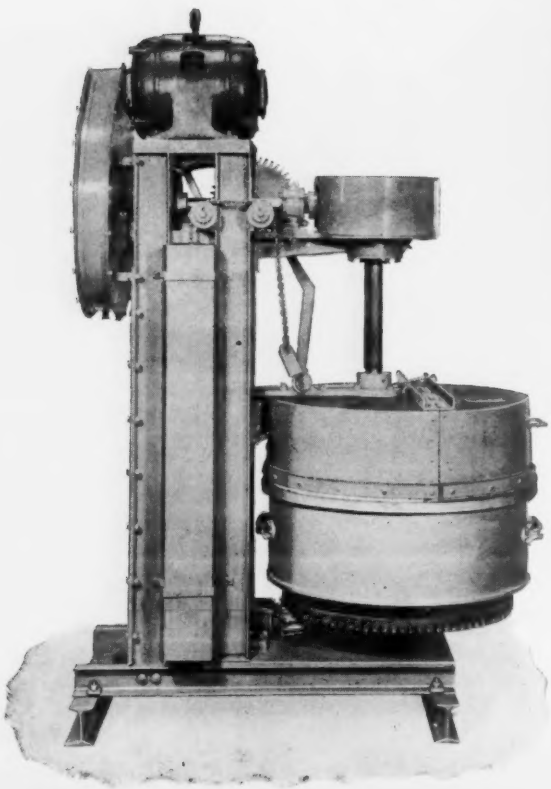

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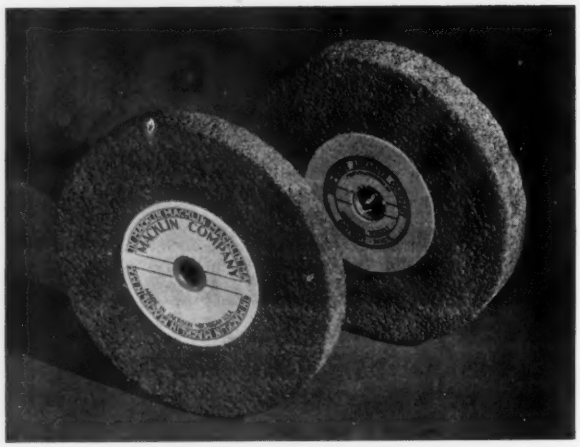

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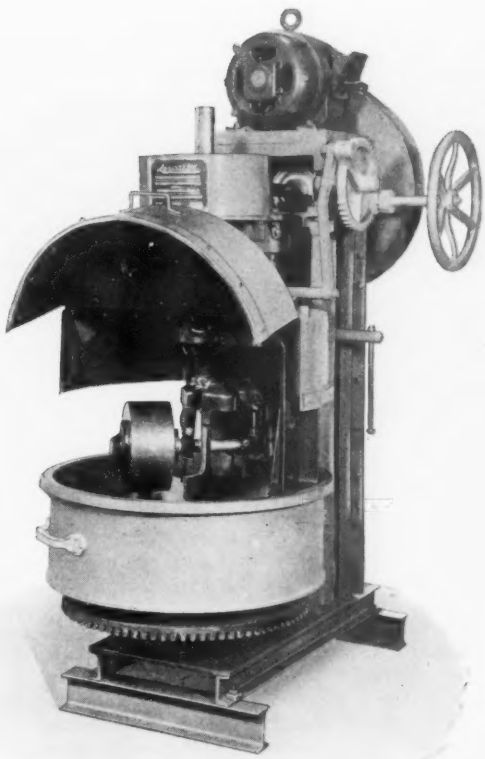

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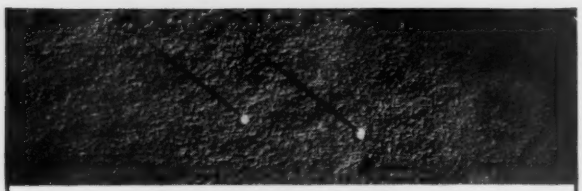

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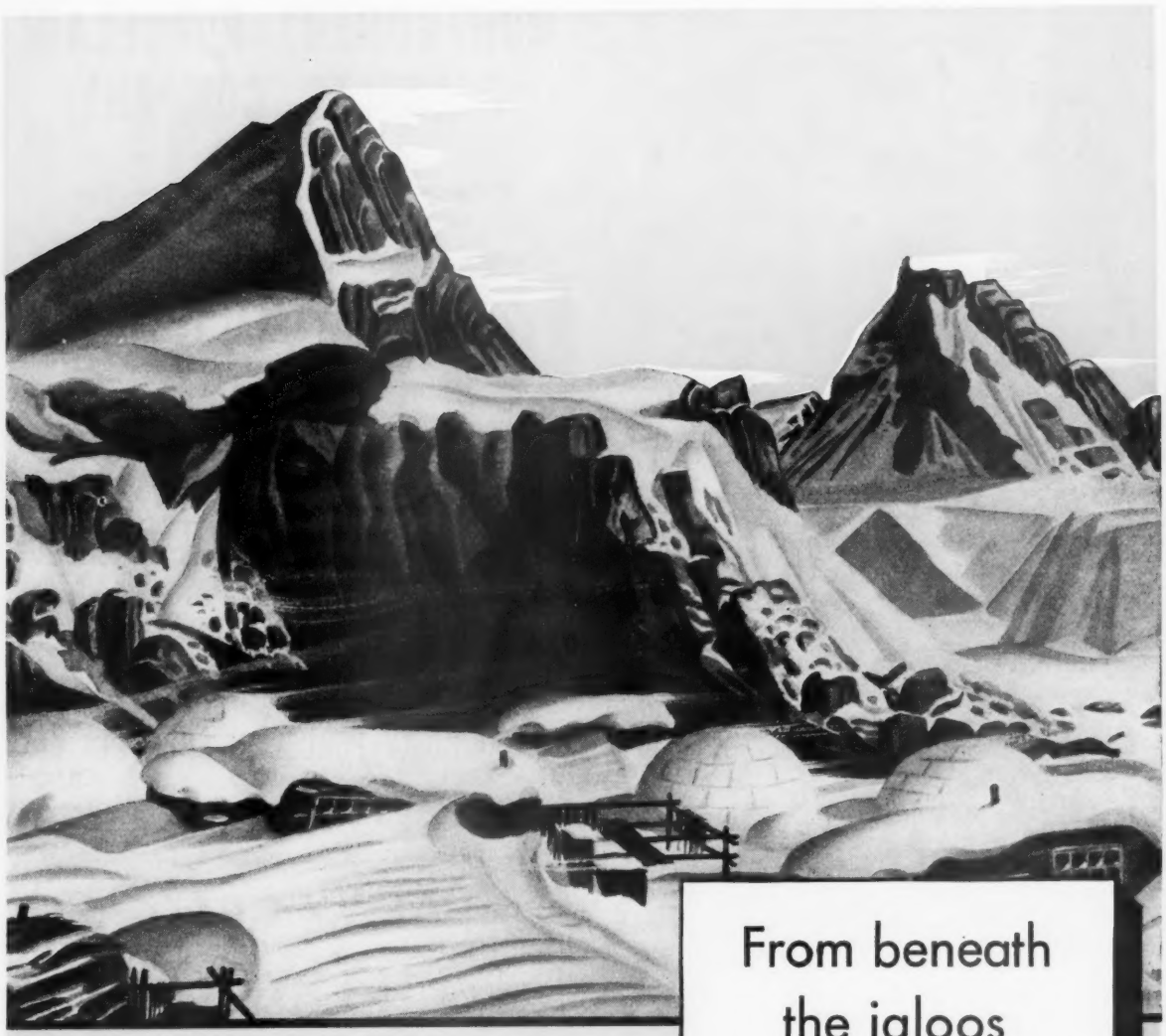

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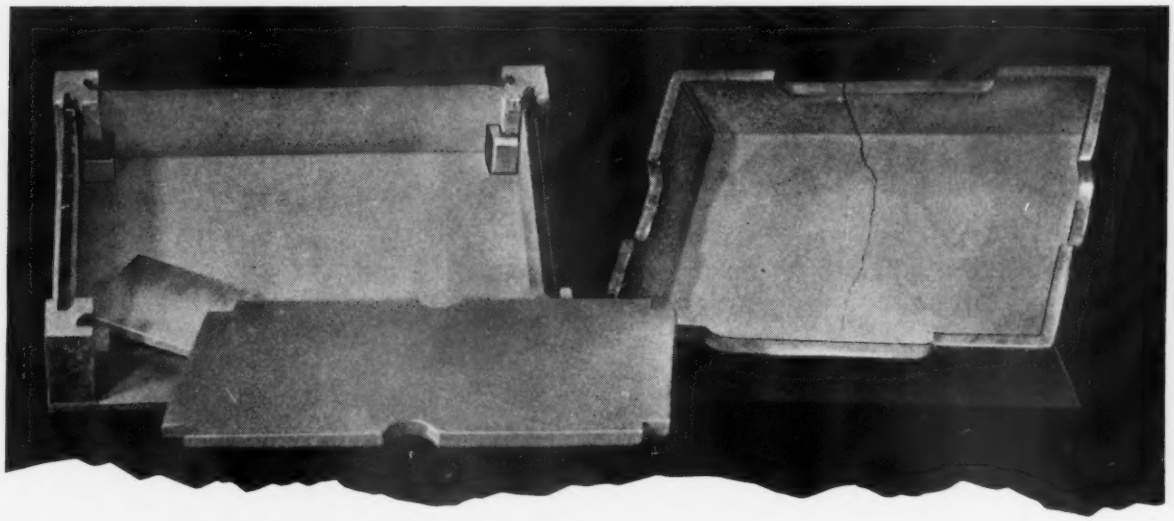

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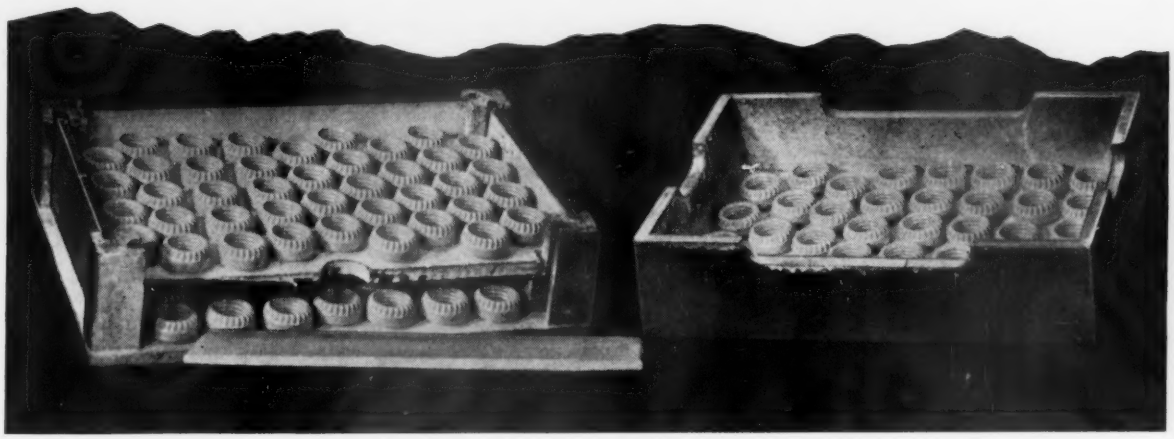

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Volume 20 AUGUST, 1941 Number 8

PAPERS

DESCRIPTION OF HOT MODULUS OF RUPTURE AND HOT CRUSHING STRENGTH TESTS AND DISCUSSION OF RESULTS*

By E. B. Hunt and R. S. Bradley

Abstract

The equipment and test procedures used to make modulus of rupture and crushing tests on refractory specimens at high temperatures are described and illustrated. The results of the tests at various temperatures are given for several types of fire-clay refractories and insulating firebrick.

I. Introduction

The tests ordinarily used to determine the strength of refractory materials are crushing strength, modulus of rupture at room temperature, and compression under load at high temperatures. Standard procedures for each of these tests, which have been accepted by the A.S.T.M., are designated as Methods of Tests C133–39 and C16–39T, respectively.

Test results are given frequently for crushing strength or modulus of rupture on samples which have been subjected to a prescribed heat treatment and then allowed to return to room temperature before testing. Although such results are interesting and valuable information has been obtained from them, they do not give any information as to the strength of these refractory materials while they were at this elevated temperature. Such information would be useful in the design of all high-temperature equipment, especially in the design of refractory shapes used in the construction of suspended arches and walls. This problem was considered to be of sufficient importance to justify the design of special equipment and the development of a test procedure.

II. Description of Equipment

(1) Modulus of Rupture

The furnace and test machine (see Figs. 1 and 2) were designed to withstand a total load of 24,000 lb. on either of the two test specimens at temperatures up to 2900°F. The steel frame supporting the hydraulic jack is structurally independent of the furnace, and the total load applied to the test specimens is taken by this frame, which is above, below, and on each side of the furnace. Because this steel frame passes under the center bottom of the furnace, it is necessary to have outlets on each side for the furnace gases. The furnace is designed to permit the control of the temperature independently on each of the two test specimens, and it is fired with open-type gas burners (using 1000 B.t.u. natural gas at 4 lb. of pressure and air at 1 lb. of pressure).

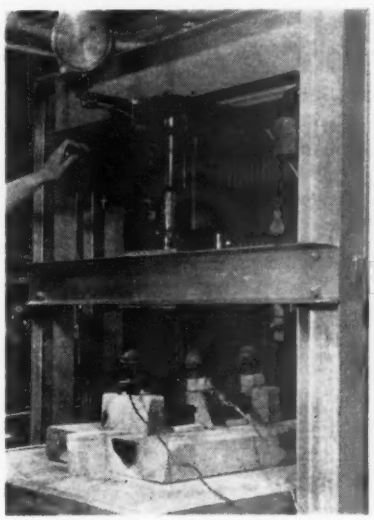

Fig. 1.

* Presented at the Forty-Third Annual Meeting, The American Ceramic Society, Baltimore, Md., April 1, 1941 (Refractories Division). Received April 2, 1941.

The 12-ton hand-operated hydraulic jack is mounted upside down on a movable base, which permits it to be moved into position to apply the load to either test specimen. This movable base slides in grooved strips fastened to the horizontal top frame of the furnace.

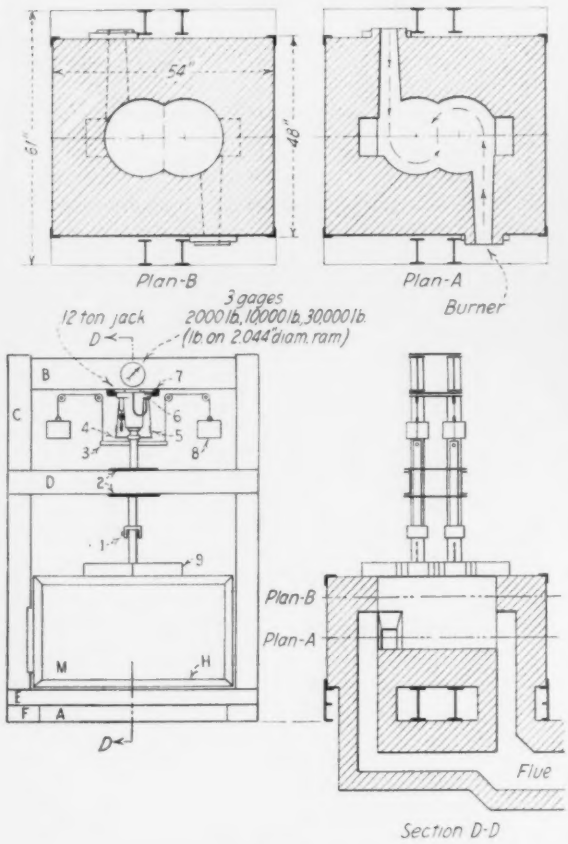

FIG. 2.

Pressure gauges are fastened on the movable base and are connected with the main cylinder of the jack by means of copper tubing. Gauges of 2000, 10,000, and 30,000 lb. capacity are used, depending on the type of refractories being tested and whether the machine is used for modulus of rupture tests or for crushing tests.

An auxiliary oil reservoir is also fastened to the movable base above the level of the pump and is connected to the cylinder with copper tubing to supply oil to the jack.

Coil springs are used between the base of the jack and the head of the piston to cause the piston to return when the pressure is released. The steel rods used to transmit the pressure from the jack to the test specimens are counterbalanced to take care of the dead load.

Refractory top bearing members are clamped on the ends of these steel rods (Fig. 3) and apply the load to the center of the top of the specimens in the modulus of rupture test. The edges of the refractory bearing members which contact the test specimens are $4^1/_2$ in. long and are rounded on a radius of $^5/_8$ in. To equalize the distribution of the load on the three refractory bearing members, the bottoms of these lower bearing members are rounded on the $4^1/_2$-in. dimension.

The spacing of the bottom bearing members on the refractory furnace base provides a 7-in. span, which is maintained by aligning the bottom bearing members with permanent marks on the refractory base. There is no slippage of the bearing members on the base until after the specimen breaks. A 95% alumina-type refractory is used for these bearing members.

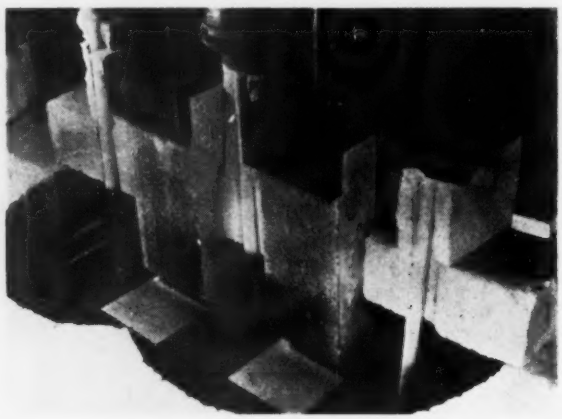

FIG. 3.

(2) Crushing Strength

The same general equipment is used for the crushing test. Figure 4 shows the setup for applying the load to the specimen. A silicon carbide brick is used to apply the load to the test specimen and a spherical bearing block is used between the silicon carbide brick and the base of the steel rods.

III. Test Procedure

(1) Modulus of Rupture

The test specimens, $2^1/_2$ by $4^1/_2$ by 9 in. in size, are set up as shown in Figs. 3 and 5. The load of the top bearing members is held off the specimens during the

FIG. 4.

heating period. The furnace is brought up to the desired maximum temperature, using schedule No. 2 (A.S.T.M. Test Method C16–39T, for the High Heat Duty Hot Load Test). It is maintained at the maximum temperature for $1^1/_2$ hours before the load is applied to one specimen at a time with the hand-operated hydraulic jack at the rate of approximately 20,000 lb. per min.

FIG. 5.

(2) Crushing Strength

Specimens with a cross section of $2^1/_2$ by $2^1/_2$ in. and a height of $4^1/_2$ in. are used because of the limited capacity of the hydraulic jack. Only the dead load of the silicon carbide brick is in contact with the test specimens during the heating period. The spherical bearing block is placed on top of the silicon carbide brick just before the load is applied.

When insulating firebrick are tested, the specimens used are $4^1/_2$ by $4^1/_2$ by $2^1/_2$ in. in size, and the load is applied to the $4^1/_2$- by $4^1/_2$-in. faces.

The same heating schedule and rate of load application is used that has been described for the modulus of rupture test.

IV. Results

Table I gives the results of tests on several types of refractory brick.

The results in most cases are the average of two tests. A recheck was made when a considerable variation occurred in the results on individual specimens or tests. A larger number of specimens, moreover, would be desirable to be sure of average results, but the data are sufficient to indicate the trend.

TABLE I

Brick No.	Room temp.	1000°F.	1400°F.	1800°F.	2000°F.	2200°F.	2400°F.
			Modulus of rupture (lb./sq. in.)				
1	800	875	855	1105	1060	1065	320
2	1415	1315	1310	1415	1300	1140	520
3	590	630	520	590	650	420	405
4	1130	1000	965	1050	1250	1200	690
5	855	855	950	870	815	350	210
6	150	145	130	165	210	168	
			Crushing (lb./sq. in.)				
1	3015	2625		Above 4000	3030		1675
3	1710	1780		3450	Above 4000		1305
6	150	155		195	235	110	

Brick No.

1 Mo. high heat-duty dry-press fire-clay
2 " " " " stiff-mud fire-clay
3 " superduty fire-clay
4 " high-fired superduty fire-clay
5 " 60% alumina diaspore firebrick
6 2300°F. insulating firebrick

V. Discussion of Results

For the types of materials tested, the results indicate a general tendency for the crushing and modulus of rupture strength to remain relatively constant from room temperature to approximately 1800°F. The strength, in most cases, is somewhat higher at temperatures from 1800° to 2000°F. The strength is considerably higher in this temperature range in the crushing test on high heat-duty and superduty fire-clay brick.

The specimens in the crushing and modulus of rupture tests failed below 1800°F. in the same manner as in the tests at room temperature. In the crushing and modulus of rupture tests above 2000°F., the specimens became compressed or they bent to some extent before they failed.

These tests have revealed properties of refractory materials on which relatively little information has been available. The data obtained do not agree in all cases with test results on the refractory products made under actual service conditions. In order to be able to make use of these tests, the results should be compiled and correlated with actual performance results, which has been necessary with all simulative tests on refractories.

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MULTIPLE-TUNNEL KILNS*

By M. S. Nelson and Hewitt Wilson†

Abstract

The use of a multiple-tunnel equivalent of a single-tunnel kiln, having the same total loading cross section and unit output, is discussed. The advantages indicated are (1) more rapid firing cycle, (2) uniformity of heat distribution, (3) higher efficiency, (4) greater flexibility and compactness, (5) lower construction cost, and (6) lower energy requirements. Such a kiln is especially adaptable to electric firing. Calculations for the multiple equivalent of any single-tunnel kiln and a table of equivalents of actual kilns are presented.

I. Introduction

One phase in the development of tunnel kilns has been directed toward kilns designed with small cross sections and for rapid rates of firing. This change has been exemplified in the United States by the erection of small straight and circular kilns, both muffle- and direct-fired, for pottery, wall tile, artware, and sanitary ware and, in Europe, by the general use of small electric- and combustion-fired kilns.[1]

Car-tunnel kilns usually operate on a much shorter firing cycle than large periodic kilns, but the maximum rate of firing has not been obtained in many instances principally because the cross section is still too large. If a more rapid firing schedule produces first-class ware in a small kiln but not in a large one, the latter probably is overloaded and the ware is packed too tightly for uniform heat distribution. Tunnel kilns of suitable cross section and length for commercial production have encountered problems in uniform temperature distribution throughout the entire firing cycle.[2]

II. Disadvantages of Multiple-Tunnel Kiln

Multiple tunnels, already in common use for the rapid drying of ceramic and other products, have been suggested for firing small articles.[1] The observation and control of the central tunnels must be carried on from the top or bottom and are not so simple as in a single-tunnel kiln. The heavy construction of periodic and car-tunnel kilns delayed the development of large inspection passages under the kilns, but the small units permit basement operations and quick repairs.

Twin-tunnel kilns were originated in the early days of car-tunnel firing, but side firing across a double-kiln width did not produce adequate uniformity in the larger cross sections. The twin-tunnel kiln (Fig. 1), however, is still in operation for glost-firing sanitary ware, and other small kilns are used in this country for glost-firing wall tile.

Fig. 1.—Small twin tunnel kiln 227 ft. long.

The interdependence of preheating and cooling cycles in counterflow firing has some disadvantages, but solutions have been suggested for most of the difficulties that might occur. The Hoffman, ring, and zigzag kilns have demonstrated that top firing and top control are feasible and safe when the crown is insulated properly and that such kilns can be made comfortable for the operators.

Electric and combustion heating can be adapted to multiple-kiln design. The width of the firebox or combustion chamber, however, in muffle- and direct-fired kilns must be reduced considerably to make a compact

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† Electrothermal engineer and supervising engineer, respectively, Electrotechnical Laboratory, Bureau of Mines, U. S. Department of Interior, Norris, Tenn.

[1] (*a*) A. Rittgen, "Electric Firing of Pottery," *Sprechsaal*, **72** [17] 209–12 (1939); translated in *Ceram. Ind.*, **32** [6] 5–6 (1939); *Ceram. Abs.*, **18** [10] 277 (1939).

(*b*) L. Bullin, "Recent Developments in Ceramic Firing," *Trans. Ceram. Soc.* (England), **35** [2] 53–96 (1936); *Ceram. Abs.*, **16** [1] 36 (1937).

(*c*) Felix Singer, "Recent Developments in German Ceramic Industry," *Bull. Amer. Ceram. Soc.*, **10** [4] 85–87 (1931).

[2] Phillip Dressler, "Problems of Firing Ceramic Ware in Tunnel Kilns," *ibid.*, **18** [11] 411–16 (1939).

unit of small periphery for a multiple kiln. The narrow-chambered, by-product coke oven (Fig. 2) indicates the possibilities in the reduction of firebox cross sections for gas and oil.

In firing certain grades of common brick and tile, fine coal is dropped through the crown of ring or Hoffman fire-moving kilns[3] and burned in contact with the ware. This method of firing has already been suggested for tunnel kilns in firing certain structural ware, and it would reduce the space between tunnels in a multiple kiln to a minimum. Remote control may be used for gas or oil firing.

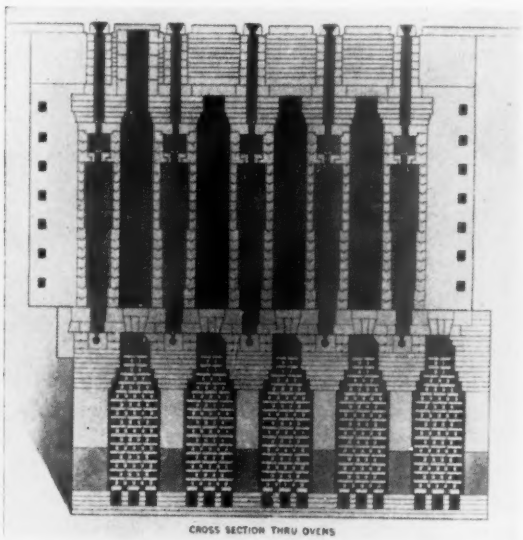

FIG. 2.—Koppers by-product coke oven.

III. Advantages of Multiple-Tunnel Kilns

The multiple kiln of small-tunnel cross section should have the following advantages: (1) more rapid firing cycle because the heat penetrates more quickly to all parts of the load; (2) greater uniformity of heat distribution for the same reason (the problems of producing even heat distribution, described by Dressler,[2] are solved more easily by multiple kilns not only because multiple sources of heat can be provided longitudinally but can be distributed transversely throughout the total setting); (3) higher efficiency within the kiln unit* owing to simpler and more direct heat recuperation between incoming and outgoing ware; (4) greater flexibility, including (*a*) more rapid production for rush orders, (*b*) different schedules and temperatures in different tunnels, and (*c*) operation of individual tunnels during slack periods with accompanying reduction in operating cost; (5) greater compactness, as less length is required for installation and operation (this is especially desirable for small factories); (6) lower initial cost of construction, indicated by smaller volume and savings in refractories; and (7) lower cost of fuel or energy because heat requirements are lower, indicated by less outside radiating surface.

In support of advantages (1) and (2), the Bureau of Mines has conducted firing-cycle and uniformity-of-firing tests on building brick in its Electrotechnical Laboratory at Norris, Tennessee. A 55-ft. electric, twin-tunnel kiln and two periodic kilns were used. Building brick were selected for the tests to provide a heavy, compact load because quality and uniformity,

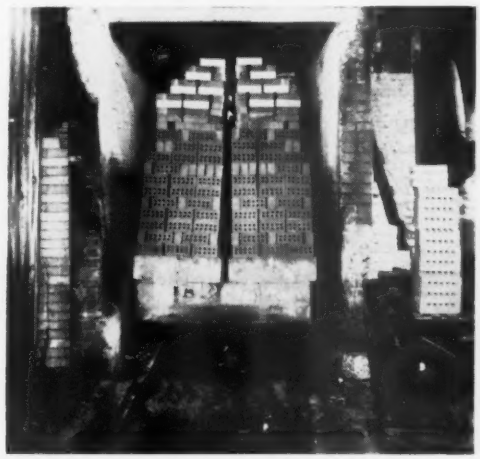

FIG. 3.—Brick setting in commercial tunnel kiln.

if obtainable with a load of this type, would be achieved more easily with open settings. A survey among manufacturers has shown that firing cycles in tunnel kilns with the larger cross sections range from 40 to 102 hr. for ware of this type. In the laboratory tunnel kiln with a cross section 12 by 12 in. in size, brick of one type were fired on an 18-hr. cycle with a setting of 66 lb. per cu. ft. The brick were comparable in all tests to the commercial product which the manufacturer fired for 102 hr. in a tunnel kiln with a 56- by 72-in. cross section. Brick of another type, fired by the manufacturer in about 7 days in a periodic down-draft kiln, were fired successfully in the laboratory tunnel kiln in 26 hr. Uniformity tests conducted in the periodic electric kilns, with a loading cross section of 16 by 21 in., gave brick of commercial quality after the equivalent of a 24-hr. firing cycle, and cone tests showed no variation throughout the cross section in the equivalent of a 48-hr. firing cycle.

The results of this investigation indicate that uniformity within commercial limits should be obtained with a 24-hr. firing cycle in a tunnel, 36 by 32 in. in cross section, which is one fourth that of the largest single-tunnel kiln covered in the survey. Figure 3 shows a commercial single-tunnel kiln for firing brick, and Figs. 4, 5 and 6 indicate how the cross section could be divided into four parts with a combined loading area equivalent to that of the single tunnel.

[3] H. N. Baumann, Jr., "Heat-Balance Study of Ceramic Kilns," *Jour. Amer. Ceram. Soc.*, **10** [11] 860–96 (1927); pp. 885–94.

* Many long tunnel kilns use heat from cooling ware for external drying and heating of the building to reduce this loss.

Advantages (3), (4), and (5) of multiple-kiln firing are self-explanatory, and in support of claims (6) and (7), an approximate method has been developed for calculating the construction of and power saving in a quadruple kiln which has the same output as a single-tunnel kiln. It is assumed here that the power requirement of a kiln is proportional to the shell area (the periphery times the length) for an equivalent ware output, insulation, wall thickness, and operating temperature. The small percentage of heat carried out by the ware and the kiln furniture is disregarded.

IV. Construction of Kiln

(1) Cross Section

The cross section of a single-tunnel kiln (Fig. 4) may be compared with its equivalent in a quadruple kiln (Fig. 5). A study of 42 commercial kilns indicates that the average space between the walls and the ware is approximately 3 in. The dead space under the arch for one large tunnel can be shown mathematically to be equal to that under four arches, each having one half the span of the single tunnel.

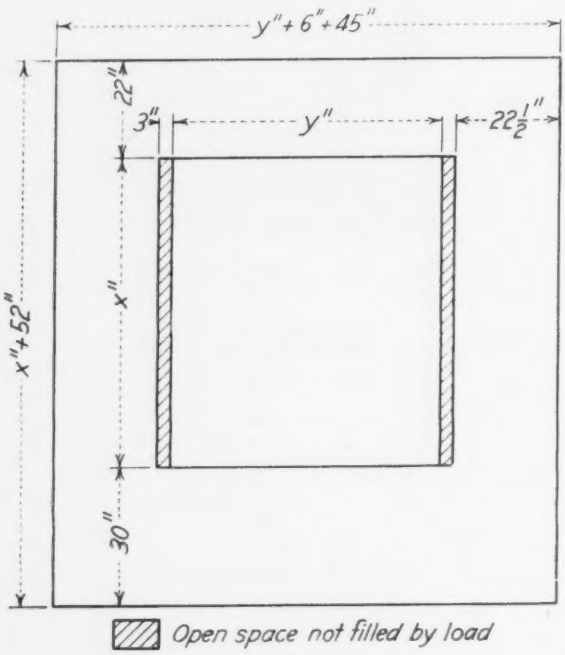

FIG. 4.—Cross section of single-tunnel kiln.

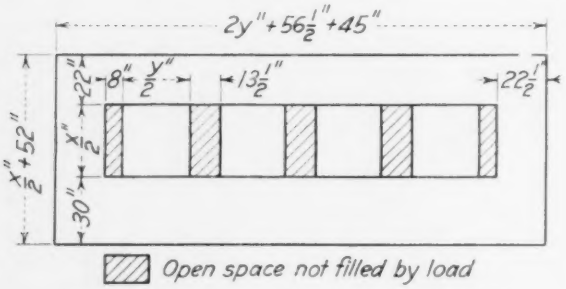

FIG. 5.—Cross section of quadruple-tunnel kiln.

If it is assumed that x equals the loading height and y equals the loading width for the single tunnel, the loading cross section per tunnel of the quadruple kiln is as follows:

$$\frac{x}{2} \times \frac{y}{2} \text{ or } 4\left(\frac{x}{2} \times \frac{y}{2}\right) = xy \text{ sq. in. for four tunnels}$$

A_s is assumed to be equal to the refractory cross section of the single kiln, which equals the height times the width minus the inside open space; similarly, if A_q is assumed to equal the refractory cross section of the quadruple kiln, then, for a single kiln (Fig. 4),

$$A_s = (y + 51)(x + 52) - x(y + 6) \text{ sq. in.}$$

A quadruple kiln (Fig. 5) will assume a value of

$$A_q = (2y + 101.5)\left(\frac{x}{2} + 52\right) - \frac{x}{2}(2y + 56.5) \text{ sq. in.}$$

$A_s = 45x + 52y + 2652$ sq. in. $(0.312x + 0.361y + 18.4$ sq. ft.)

$A_q = 22.5x + 104y + 5278$ sq. in. $(0.156x + 0.722y + 36.6$ sq. ft.)

(2) Periphery

If P_s is assumed to equal the periphery of the single kiln [$2(y + 51 + x + 52)$ in.] and P_q to equal the periphery of the quadruple kiln [$2(2y + 101.5 + x/2 + 52)$ in.], then

$P_s = 2x + 2y + 206$ in. $(0.167(x + y) + 17.17$ ft.)

$P_q = x + 4y + 307$ in. $(0.083x + 0.33y + 25.58$ ft.)

(3) Length

If L_s equals the length of the single kiln and L_q, the length of the quadruple kiln, then

$$L_q = \frac{S_q L_s}{S_s},$$

Where S_s = firing schedule of single kiln (hr.)
S_q = firing schedule of quadruple kiln for same output

Then

$$\left(1 - \frac{A_q L_q}{A_s L_s}\right) \times 100 = \% \text{ of savings in construction}$$

$$\left(1 - \frac{P_q L_q}{P_s L_s}\right) \times 100 = \% \text{ of savings in power input.}$$

(4) Kiln Equivalents

The following calculations may be made on the quadruple-kiln equivalent of a single-tunnel kiln 376 ft. long, with a loading cross section 64 in. high and 59 in. wide, operating on a 96-hr. firing cycle. The kiln is to operate on a 24-hr. cycle.

$$\frac{x}{2} = \frac{64}{2} = 32 \text{ in. (loading height)}$$

$$\frac{y}{2} = \frac{59}{2} = 29.5 \text{ in. (loading width)}$$

$$L_q = \frac{S_q}{S_s} \times L_s = \frac{24}{96} \times 376 = 94 \text{ ft. long}$$

$A_q = 0.156(64) + 0.722(59) + 36.6 = 89.2$ sq. ft.

$A_s = 0.312(64) + 0.361(59) + 18.4 = 59.7$ sq. ft.

$P_q = 0.083(64) + 0.33(59) + 25.6 = 50.6$ ft.
$P_s = 0.167(64 + 59) + 17.2 = 37.8$ ft.

$$\text{Refractory saving} = \left(1 - \frac{89.2 \times 94}{59.7 \times 376}\right) \times 100 = 62.6\%$$

$$\text{Power saving} = \left(1 - \frac{50.6 \times 94}{37.8 \times 376}\right) \times 100 = 66.6\%$$

Table I gives the quadruple-kiln equivalents of six commercial, single-tunnel kilns for the 24- and 36-hr. firing cycles. For kiln No. 3 and others where little difference is found between the present single-tunnel firing cycle and that of the proposed quadruple-kiln cycle, there would be an actual loss in savings on refractories and power input; considerable savings, however, are shown on a proposed 24-hr. cycle and there is less saving for the proposed 36-hr. cycle when the present cycle is 59 hr. or more. Many clays and products, of course, cannot be fired at the proposed rapid rates.

(5) Car-Deck Areas

Savings in refractory and power costs will be accompanied by savings in car-deck areas as well as in car construction. The deck area required to fill a single-tunnel kiln equals the loading width times the length, or $(x)(L_s)$. The deck area for a quadruple kiln is $(4x/2 \times L_q)$. The ratio of the deck areas therefore is $L_s/2L_q$ for the same volume of production; or, because $L_s/L_q = S_s/S_q$, the same ratio may be obtained from the schedules, $S_s/2S_q$. These ratios show that the quadruple-deck area is the same as that of the equivalent single kiln if the quadruple cycle is one half that of the single cycle and is less for more rapid quadruple cycles.

(6) Number of Cars

A division of one large tunnel into four small tunnels quadruples the number of cars for the same firing cycle and length of kiln, but the number remains unchanged if the cycle or length is quartered. When more cars are required, they will be narrower and carry less load per square foot, and each car therefore will cost less; each car, however, must make four cycles to carry the equivalent of one large car. Cars or deck areas required for operations outside the kiln have not been considered in this discussion.

V. Electric-Fired Multiple-Tunnel Kilns

Electric firing approaches the direct-contact efficiency and rapid flexibility of open firing and provides the clean atmosphere of the best muffle kiln. For the higher temperatures, such as those used for porcelain, electricity has been applied only to kilns of comparatively small cross section, the maximum size reported[1(a)] being only 2.1 by 3.3 ft. These dimensions, however, are not the largest using radiation and natural convection. Large muffle-tunnel kilns are now in service, and periodic muffle kilns holding a maximum of 100 tons of terra cotta plus kiln furniture have been used successfully without forced convection. Metal-wire resistors for low temperatures and vertical nonmetallic rods and tubes for the higher temperatures can be inserted between tunnels in multiple-tunnel kilns without increasing the width beyond structural requirements. The heating elements may be exposed to the ware or they may be concealed partly or completely by shields or secondary radiators, according to the requirements of the product. The internal design of electric kilns can probably be simplified greatly because the firing chambers, flues, checkerwork, dampers, draft, pressure-control devices, and stacks can be eliminated. Vertical elements may be repaired or replaced from the top and bottom in such installations, and the resistors heated by low voltage may be handled without danger. The contacts for electric elements require practically no attention after they are installed until replacements are necessary. The high-temperature cutting and melting action of oil flames is not encountered with electric heating.

The preceding calculations of refractory savings disregard the extra volume and area required for muffle walls, burner ports, checkerwork, and double crowns in

TABLE I

KILN EQUIVALENTS

	Number	Single kilns now in service					
		1	2	3	4	5	6
Length (ft.)		376	312	350	390	289	376
Cycle (hr.)		96	102	40	59	59	74
Load height (in.)		64	72	60	70	73	68
Load width (in.)		59	56	60	60	64	58
Loading (lb./cu. ft.)		60	72	63	58	100	60
Output (lb./hr.)		5965	7220	13,800	11,000	15,800	8270
		Quadruple kiln, 24-hr. cycle (proposed)					
Length (ft.)		94	74	210	159	118	122
Load height (in.)		32	36	30	35	36.5	34
Load width (in.)		29.5	28	30	30	32.0	29
Refractory saving (%)		62.6	65.7	8.8	40.1	40.2	52.2
Power saving (%)		66.6	69.1	18.5	46.0	46.1	58.1
		Quadruple kiln, 36-hr. cycle (proposed)					
Length (ft.)		141.0	110	315	238	177	183
Refractory saving (%)		44.0	49.1	−37.0	10.4	10.5	28.5
Power saving (%)		50.0	54.1	−22.0	19.1	19.1	37.0

combustion-fired kilns. Because these areas involve considerable space in some kilns, the calculations should be conservative for an electric-fired, multiple-tunnel kiln. These calculations, moreover, do not consider the higher efficiency of electric heating resulting from the absence of stack losses, and the estimated power savings are therefore more conservative.

The initial cost of accessory equipment, including transformers, resistors, and control equipment, will be higher for an electric kiln than for a fuel-fired kiln; this extra cost, however, will be partly offset by an equivalent automatic control for the better types of combustion burners and their accessory equipment, as well as by the simpler and less expensive kiln construction. It is also important to use the best thermal insulation in electric-kiln construction because of the higher unit cost of energy.

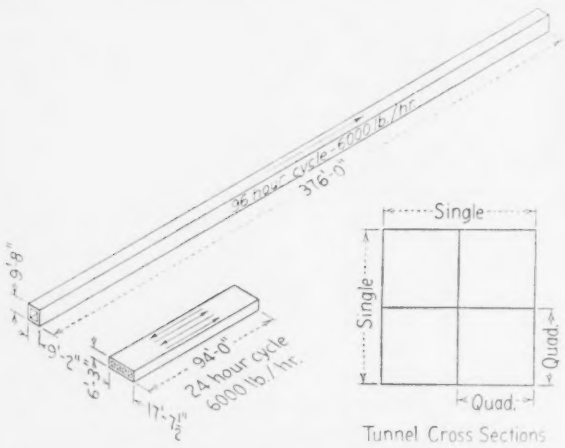

FIG. 6.—Quadruple equivalent of single tunnel kiln.

Although the firing of brick by electricity has been considered in this study, the electric kiln would probably be more useful in the manufacture of ware that is difficult to fire, such as abrasives, decorated and glost ware, electrical porcelain, and sanitary ware. Figure 7 shows a piece of sanitary ware that was fired successfully in one of the laboratory periodic kilns with exposed elements; the ware was placed within 3 inches of these elements. Ware of this type is fired in the equivalent of a 52-hr. tunnel-kiln cycle and a 36-hr. cycle has been used without the occurrence of dunting.

VI. Conclusions

(1) A short, multiple-tunnel kiln should have many advantages over the present large, commercial, single-tunnel kiln; for example, more rapid firing cycles, equal or greater uniformity of heat distribution, higher kiln efficiency, greater flexibility and compactness, less volume of refractories and lower cost of construction, and lower energy requirements for same output.

(2) Electric and combustion heating may be adapted to multiple-kiln design, although the simple, compact construction of an electric kiln should make it more adaptable.

FIG. 7.—Electrically fired sanitary ware.

(3) Although more cars may be required in a multiple-tunnel kiln, the car-loading area will usually be less and cars and rails will be lighter in weight because the load per car is lighter.

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DEAIRING FINE CLAY BODIES IN THE PLASTIC FORM*

BY E. A. HAWK

ABSTRACT

A new method of deairing fine ceramic materials is described, and an account is given of experiments in processing and the results obtained.

I. Introduction

The English Bolton pug mill is used to work filter-press clay leaves into a mixed roll suitable for jiggering without deairing the material; the use of this mill gives a uniform moisture content to the plastic mass.

By proper designing and setting of the knives, these mills, on limited capacities, produce a clay roll free from visible openings. If the capacity is increased and the knives are not properly designed and set, the clay roll produced is tender, easily broken, has visible

* Presented at the Forty-Third Annual Meeting, The American Ceramic Society, Baltimore, Md., April 2, 1941 (Materials and Equipment Division). Received April 2, 1941.

openings, and is full of intrapped air. The moisture must be uniformly distributed throughout the mass.

It is important to make the moisture content uniform in the clay, but this is a separate process from deairing.

II. Disadvantages of Pug Mills

Two difficulties usually encountered in clay-mixing mills are (1) the variation in the capacity of the mill in relation to the moisture content of the material (as the material becomes more moist, the capacity decreases) and (2) the design and set of the knives.

These difficulties have been lessened by the use of a fluted surface inside the mill. The flutes in some cases are parallel with the shaft of the mill, or they may circle the periphery of the mill. A combination of these flutes is often used.

Fluting also introduces openings at the back of the mill. With a normal clearance between flutes and knife or screw equipment, a differential clay flow is obtained. When the clay is compressed for extrusion through the die opening, a certain percentage of the material flows back through these flutes over the knives. The effectiveness of the flutes varies with the moisture content of the material, that is, they function more successfully on the drier materials than on wet mixes.

III. Deairing Problems

In the mixing mill, it is necessary to have only a container in which a shaft, carrying a series of knives, mixes the material, carries it forward, and extrudes it in a finished roll of clay.

The deairing of clay, however, requires that a vacuum be maintained while the material is moving. As the material enters the deairing compartment, it must act as a seal, as also must the outgoing material. These seals are subjected to atmospheric pressure.

Proper evacuation of clay can be obtained only when the deairing compartment is partly filled with clay; the remainder of the chamber is an open space subjected to approximately 28.5 in. of vacuum, which varies according to altitude and barometric readings.

A continued maintenance of approximately 10% of clay and 90% of evacuated space presents problems. (1) Because the incoming material acts as a seal, the input die is subjected to atmospheric pressure. (2) The moisture content affects the amount of material delivered in unit time as well as the capacity of the discharge end. When the moisture content rises, for example, the input die delivers more material in unit time, whereas the discharge die delivers less material per unit time under these same conditions. (3) The amount of material delivered is also affected by the pressure exerted by the incoming material.

When more material is fed through the intake opening than can be extruded, the deairing compartment fills up and insufficient deairing occurs.

IV. Maximum Deairing

There are three methods of removing air from clay, namely, (1) the plastic body may be cut open, thereby exposing the bubble; (2) the air pocket may be removed by increasing the pressure against the plastic bounds of the air pocket, causing the material to rupture and to release the air (this pressure is accomplished by the use of vacuum); and (3) the plastic material may be subjected to pressure, thus compressing the air pocket and causing it to rupture its casing wall.

Maximum evacuation is obtained when the plastic mass has the greatest amount of surface exposed to the highest vacuum while the material is being subjected to the greatest pressure for the longest time.

The most efficient deairing machine depends on suction, pressure, and time. A constant ratio must be maintained between space and material in the evacuating compartment. Pressure is exerted on the material by the use of centrifugal force, whereby a portion of the machine is rotated (that is, a revolving barrel) instead of the shaft. The material moves to the periphery of this revolving barrel, which is equipped with a set of stationary knives. The material under pressure is chopped by centrifugal force at the periphery of the revolving barrel.

To facilitate the vacuum requirements, the revolving barrel is telescoped over an input opening. There is an opening between the inside of the barrel and the outside of the input opening. This opening in the telescope joint is provided with screws, which permit the passage of air and bar the passage of material.

To guarantee the uniform passage of material through the machine, the traction on the inside of the rotary evacuation chamber is increased by introducing a steel screen lining. This screen performs the following important functions: (1) it increases the traction of the forward movement of the material; (2) it prevents the backward flow of the material over the knives, and (3) it protects the surface of the revolving barrel from wear by maintaining a coating of clay. The ratio of 10% of material and 90% of space is maintained under all moisture conditions by running the revolving evacuating chamber and the extrusion equipment at ten times the speed necessary to produce the recommended capacity, thus permitting the input of the evacuating compartment to control the output capacity.

All of the internal equipment is made to run eccentric instead of concentric as in most deairing machines. The most important function of this eccentricity is the elimination of gas particles which form openings in the final extrusion.

Six of these machines are being used in potteries in this country. They have given satisfactory results and, in every case, have produced a uniform product.

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PREFABRICATED STRUCTURAL CLAY TILE FLOOR SYSTEM*

By E. F. Wanner

Abstract

A description is given of the development, test methods, and results showing the application of prestressed ceramic building members in modern construction. Comparisons are presented on (1) the effect of grouted vs. ungrouted reinforcing bars subjected to the same degree of prestressing and (2) thin mortar joints and ground end units without mortar to develop the maximum compressive resistance inherent in structural clay-tile bodies.

I. Introduction

The standardization of test methods, developed by the Federal authorities and distributed to various manufacturers,[1] has encouraged a large amount of private industrial research. The test methods used in this paper conform essentially with the procedure suggested by the National Bureau of Standards.[2] Emphasis in this research has been placed on adequate engineering design and on the economic factor. Only the engineering phase, however, is to be considered here, although the importance of the relative cost of competitive materials is always of primary interest.

The strength of structural clay tile has long been accepted without question by architects and engineers who are familiar with the conservative practice of designing with factors of safety from 6 to 12 for structural tile as compared with $2^1/_2$ to 5 for steel and concrete.

II. Factors Affecting Design Loads

From many test results showing high compressive strengths consistently obtained on structural clay-tile units, it is difficult to understand why a working stress of only 75 lb. per sq. in. is usually recommended for horizontal cell load-bearing units in which many commercial tile designs often exceed from 2500 to 4000 lb. per sq. in. on the gross area. It is recognized that, when these units are used in walls or piers, the combined unit strength is determined by the variable factors of workmanship and average mortar strength.

Of these factors, the mortar strength generally determines the strength of the assembly. This is readily understood because the commonly specified ratio of 1 to 1 to 6 (cement to lime to sand by volume) develops a compressed strength of approximately 500 lb. per sq. in. in air storage, whereas a ratio of 1 to 0.25 to 3 (cement to lime to sand by volume) develops approximately 1500 lb. per sq. in. This increase is directly reflected in actual tests of built-up wall sections. Consideration, therefore, obviously must be given to the coordination of materials of known strength whereby the high unit strength that is inherent in ceramic units may be developed.

III. Effect of Prestressing

This coordination was suggested by preliminary study and tests[3] on assembled building members with prestressed reinforcing bars, in which important economies of material, time, and labor could be obtained by a proper utilization of the materials so that the maximum efficiency or strength characteristic could be developed.[4]

It was apparent that prestressing compacted the mortar joints between the individual ceramic units so that the maximum unit area was in intimate contact. The mortar itself, being compacted, also developed greater strength and better bond. A beam or slab section of prefabricated ceramic units with prestressing, induced by stretching or tightening of the main-tension reinforcing rods, receives a fundamental change, the maximum effect of which can be determined only by actual load tests.

The lower fibers, in theory, are compressed as the tension is increased in the steel, causing an apparent rise of the neutral axis above its normal position. After the assembled sections are placed in position to form a floor panel, the initial loads, while increasing the steel tension, neutralize the initial compressive prestress in the lower fiber. As the loads are increased, the neutral axis continues an apparent movement toward the bottom of the section while the lower fibers resist the normal tensile stresses.

This theory recommends the selection of reinforcing steel with a high yield point. These experiments, however, were conducted with intermediate grade steel of an increased area inasmuch as the objective was to determine, if possible, the full resistance of the structural tile.

IV. Factors Contributing to Design

In the promotion of a prefabricated roof system consisting of ribbed hollow fired-clay units, the reluctance of designers to accept the theory of prestressing was appalling, although preliminary tests demonstrated the exceptional total loads that could be sustained. A particular objection was found to be the use of reinforcing placed through a circular core of the tile without the customary mortar encasement. This objection suggested the necessity of additional comparative tests and the development of a flat ceiling type suitable for floor construction. This series of tests sustained the

* Presented at Forty-Third Annual Meeting, The American Ceramic Society, Baltimore, Md., April 2, 1941 (Structural Clay Products Division). Received April 17, 1941.

[1] Circular Letter LC-502A, National Bureau of Standards, Washington, D. C., August 6, 1937.

[2] Building Material and Structures Report BMS2, August 10, 1938, National Bureau of Standards, Washington, D. C.

[3] F. O. Anderegg and C. L. Dalzell, "Prestressed Ceramic Members," *Proc. A.S.T.M.*, **35** (Part II) 447–56 (1936); *Ceram. Abs.*, **15** [4] 124 (1936).

[4] F. O. Anderegg, "Super-Ceramic Building Members," *Jour. Amer. Ceram. Soc.*, **20** [3] 77–79 (1937).

results obtained from a preliminary ribbed roof-deck design and demonstrated the advantage of grouted prestressed reinforcing.

All of these tests were conducted on structural units produced by a special manufacturing process whereby the density of the material is reduced from 20 to 25%. This method produced units with high insulation value at some sacrifice of the total compressive strength. Actual tests on the units, however, demonstrated that a balanced product could be obtained which retains greater unit compressive strength than the commercial Portland cement concretes used in present-day designs. Tables I and II give results from the tests obtained on units that were reduced approximately 25% in weight compared with the normal clay density.

TABLE I

TEST RESULTS ON CLAYSPAN TILE

Compression Test—Made on End with Cell in Vertical Position

Specimen No.*	Weight (lb.)	Weight (oz.)	Calculated (sq. in.) Gross area	Calculated (sq. in.) Net area	Crushing strength (lb./sq. in.) On gross area	Crushing strength (lb./sq. in.) On net area
1	22	6	69.1	34.95	2315	4580
2	22	8	69.1	34.95	2765	5470
3	22	6	69.1	34.95	3220	6375
4	22	12	69.1	34.95	2400	4750
5	23	13	69.1	34.95	2570	5080
Avg.					2652	5251

* Nominal size; 12 by 6 by 12 in.

TABLE II

ABSORPTION TEST RESULTS*

Specimen No.	Weight (gm.) Initial	Final	Gain	Absorption (%)
1	1379.0	1625.5	246.5	17.9
2	1231.9	1455.2	223.3	18.1
3	1237.4	1461.8	224.4	18.1
4	1159.0	1352.6	193.6	16.6
5	1751.5	2065.3	313.8	17.9
Avg.				17.7

* 1-hr. boil method; 2 pieces taken from the shell and 1 from the web of each tile were given the compression test.

Test results on the thermal conductivity of the processed clay by the hot-plate method demonstrated the high insulation value that may be attained in the mass or body of the tile. The actual coefficients for dense clay vary from 5.0 to 9.2 B.t.u. per sq. ft., per hr., per in. thickness, per °F. difference in temperature between the two surfaces. A k value of 8.0 is used generally for clay of normal density; by actual test, a conductivity coefficient of $k = 2.11$ was obtained on the lightweight clay. This reduction, together with the cored construction of structural clay-tile units, indicates that a highly insulated product is obtained.

V. Assembly of Beams

Beams for Clayspan panels Nos. 1 to 4 were assembled from lightweight units having ordinary wire-cut ends. Mortar consisting of 1 part of Portland cement to $2^1/_2$ parts of sand with 25% of 1 part of pure fire clay added to provide workability was used between the individual units. The test results on this mortar (Table III) indicated that compressive strength consistent with the unit strength of the tile may be obtained if it is properly cured.

TABLE III

TEST RESULTS ON JOINTING MORTAR

Compression test on 2-in. cubes (lb./sq. ft.)

Water storage at 7 days	Water storage at 28 days
3750	5595
4062	5690
4125	5400
Avg. 3979	5562

In comparing the 28-day mortar strength of 5562 lb. per sq. in. with the tile crushing strength of 5251 lb. per sq. in. on the net area, a desirable consistency was found to exist between the two materials.

Because of the high absorption of the units, they were thoroughly soaked in water for several minutes before mortaring. The units were assembled on a heavy wood plank provided with a straight edge on one side. A wood block at the starting end permitted successive units to be shoved tightly into position.

Beams for panel No. 5 were made from Clayspan units having machine-ground ends which were assembled without mortar between individual units. This method has desirable advantages, and with proper equipment to maintain perfect end surfaces in planes truly perpendicular to the horizontal axis of the tile, the obvious economic advantages of this method will recommend its practical use in construction.

The individual beams for panel No. 1 were made from special kerfed units which permitted a narrow strip of tile to be removed from the bottom shell at the reinforcing core. This enabled the units to be assembled with the lower tension rod completely encased in grout. The units were placed on the plank form in an inverted position, with one $^3/_8$-in. ϕ auxiliary bar threaded through the small circular core near the upper or compressive surface of the beam. This rod assists in obtaining symmetrical compression in the beam by prestressing to overcome the camber or buckling tendency as the heavy main tension reinforcing bars are prestressed. The auxiliary bar usually is not required in actual practice, particularly in the beams that are 4 in. and 5 in. thick unless they are to be subjected to rough handling. After the beams are in position and partly loaded, the upper rod may be removed if desired.

After the $^3/_8$-in. ϕ rod was partly tightened, a small amount of grout was placed in the bottom groove over the full length of the beam. The $^3/_4$-in. ϕ main tension rod was set in the bed and covered with mortar. It was immediately prestressed to the same degree as the beams for the other panels, and the grout was thoroughly compacted around the reinforcing.

VI. Erection of Panels

After a curing period of 5 days, panels Nos. 1 to 4 were assembled on the prepared wood-block supports. Each panel was approximately 3 ft. wide consisting of

three beams, each 12 in. wide. The tested clear-span length was 12 ft. for all panels with $^3/_4$-in. ϕ reinforcing, except panel No. 4 which was 14 ft. between supports with $^7/_8$-in. ϕ reinforcing. Panel No. 5, with machine-ground joints, was erected on the wood-block supports within a few hours after the individual beams were assembled. Because these beams contained no grout between units, they were placed immediately on the supports. When grouted rods are used, the beams should be cured for at least 24 to 48 hr. before they are placed on the supports.

After the panels were in position, forms were built around the tops of panels Nos. 3 and 4 in preparation for the 1-in. thick cement topping. The proportions for this grout consisted of 1 part of cement to $2^1/_2$ parts of sand. This mixture was also used for the jointing material between the individual beams. A very wet mix was necessary for this operation because the original design included one concave and one convex side on each beam and very little space was provided for the grout to enter. This design was intended to provide an interlocking feature. An improved design, however, is concave on both sides to permit a space for additional reinforcing if it is required. As this space is easily filled with grout, it contributes greatly to the rigidity and consequently to the lateral strength of the panel.

Test cubes, made from the topping grout, and three cubes were tested at 7 days and three at 28 days. The results of these tests are shown in Table IV.

TABLE IV

TEST RESULTS ON TOPPING MORTAR

Compression tests on 2-in. cubes (lb./sq. ft.)

Water storage at	
7 days	28 days
2375	3750
2250	3725
2300	3925
Avg. 2308	3800

VII. Method of Testing

All panels were simply supported on 1-in. diameter steel rods, spaced as previously indicated. There was no capping of the specimen on the under side to insure a uniform load across the panel support. The load was applied to the panels through a wooden platform which rested on pipe, approximately $1^1/_2$ in. in diameter and which in turn rested on steel plates about $1^3/_4$ in. wide, running the full width of the test panels. These bars had uniform bearing across the top as the panel was provided with mortar caps at the bearing points. The total load was thus applied uniformly along two transverse lines, each one fourth of the span from the support, known as quarter-point loading. All panels had been aged from 28 to 30 days at the time of testing, and after their erection, they were cured for 5 days under wet burlap. The procedure and method of testing conformed with the suggestions of the U. S. Department of Commerce.[1]

Deflections were recorded with two Ames dials reading to 0.001 in., placed at the center of the panel longitudinally and approximately one fourth the panel width from either edge.

The panel set was determined by removing the load after the equivalent superimposed design load of 40 lb. per sq. ft. was reached for the panels without topping and 50 lb. per sq. ft. for panels Nos. 3 and 4 with topping. The load was also removed and the total set was determined at two and one-half times the design load. The panels were then reloaded to the failure point with deflections recorded with a scale reading to $^1/_{50}$ in. The ultimate superimposed load divided by 4 was used as a basis to determine the safe working loads.

VIII. Comparisons and Results

(1) Panel No. 1

This panel with grouted rods developed the greatest strength of the five test panels. An equivalent superimposed uniform load of 375 lb. per sq. ft. was recorded at failure (see Figs. 1 and 2). This load was 100 lb. per sq. ft. greater than panels Nos. 3 and 4, both of which were constructed with a cement topping 1 in. thick. A comparison of panels Nos. 2 and 3 shows that the topping increased the total uniform load approximately 45 lb. per sq. ft. With a cement topping on panel No. 1, this amount of increase in load at least could be expected. Computations indicate that an increase of approximately 85 lb. per sq. ft. could be attained because of the greater depth, provided a similar tension failure occurred.

FIG. 1.—Clayspan panel No. 1.

FIG. 2.—Clayspan panel No. 1.

As a demonstration of the rigidity of structural clay-tile floor systems, the load was removed from panel No. 1 after a total load of 10,200 lb. or 280 lb. per sq.

ft. was reached, where a deflection of 0.667 in. was recorded. This panel immediately recovered to within 0.135 in. of the original unloaded position after the load was removed.

TABLE V

SUMMARY OF PANEL DATA

	Panel No.				
	1	2	3	4	5
Slab thickness (in.)	6	6	7	7	6
Topping	None	None	1-in. cement	1-in. cement	None
Joints	Mortar	Mortar	Mortar	Mortar	Machine ground
Length (ft., in.)	13, 3 1/2	13, 2 3/4	13, 2 3/4	15, 3 1/4	12, 9 7/8
Span (ft., in.)	12, 0	12, 0	12, 0	14, 0	12, 0
Width (ft., in.)	3, 0	3, 0	3, 3/8	3, 3/8	3, 0
Avg. weight (lb./sq. ft.)	25	25	37	37	25
Tension steel (in. ϕ)	3/4	3/4	3/4	7/8	3/4

TABLE VI

SUMMARY OF TEST DATA

	Panel No.				
	1	2	3	4	5
Lb./sq. ft.	Total deflection (in.)				
40	0.060	0.0525			0.070
0	0.0035	0.001			0.022
50			0.0425	0.093	
0			0.0035	0.011	
100	0.190	0.2665			0.2035
0	0.0145	0.003			0.0325
125			0.2155	0.420	
0			0.0235	0.020	
	1/360 of span (in.)				
	0.400	0.400	0.400	0.466	0.400
	Load at 1/360 deflection (lb.)				
	192	125	187	132	162
	Last reading (in.)				
	1.59	1.15	0.702	1.450	0.9775
	Load failure (lb./sq. ft.)				
	375	230	275	274	260
	Failure*				
	T	C	C	C	C

* T = steel in tension; C = crushing of tile under washer.

(2) Panel No. 2

The failure load of 230 lb. per sq. ft. may be compared directly with panel No. 1 where all conditions were equal except for the grouted rods. (Panel No. 1, as stated previously, sustained an equivalent uniform load of 375 lb. per sq. ft or an increase of 60% over panel No. 2.)

All panels except No. 1 failed suddenly when the end tile were crushed immediately under the washer. The deflections, which were generally greater than 1 in., contributed to the failure by adding a vertical component to the horizontal compressive force under the washer. This vertical force reacted on the lower shell of the end units, causing a combination of flexural and compressive failure. The bond resistance of the grouted rods prevented this type of failure in panel No. 1.

(3) Panel No. 3

This panel compares directly with panel No. 2 with all conditions similar except the addition of a 1-in. cement topping. Very low deflections were noted, and although the immediate set after the 125-lb. equivalent unit load was removed was negligible, it was almost eight times greater than that of panel No. 2 after removing the 100-lb. load. A 24-hr. recovery period would reduce this difference considerably.

Failure of panel No. 3 occurred at 275 lb. per sq. ft. or at 100 lb. less than panel No. 1 with grouted rods and 1 in. less effective steel depth.

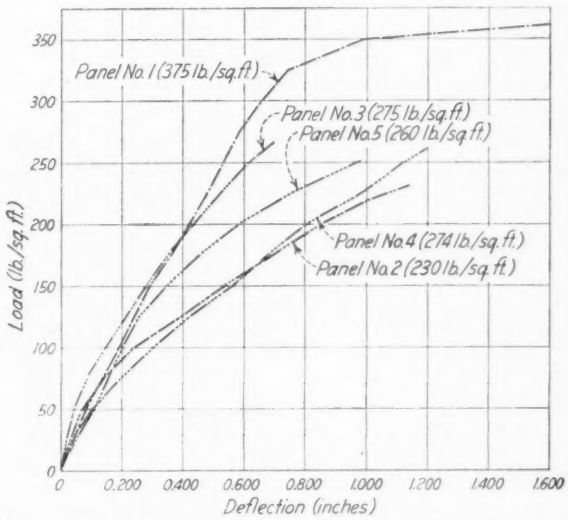

FIG. 3.—Loading and deflection curves for Clayspan panels.

	Panel No.*				
	1	2	3	4	5†
Length (ft., in.)	13, 3 1/2	13, 2 3/4	13, 2 3/4	15, 3 1/4	12, 9 7/8
Span (ft., in.)	12, 0	12, 0	12, 0	14, 0	12, 0
Width (ft., in.)	3, 0	3, 0	3, 3/8	3, 3/8	3, 0
Topping (ft., in.)	None	None	0, 1 (cement)	0, 1 (cement)	None
Steel (in. ϕ)	3/4‡	3/4	3/4	7/8	3/4

* On each panel, panel thickness, 6 in.; aging time, 28 days; quarter-point loading.
† Joints, machine ground.
‡ Imbedded in mortar.

(4) Panel No. 4

The unit failure load of 274 lb. per sq. ft. recorded for this panel on a 14-ft. span with 7/8-in. ϕ reinforcing steel is approximately the same as the total uniform load sustained by panel No. 3 with 3/4-in. ϕ bars on a 12-ft. span. For similar unit loads, the total measured deflection for panel No. 4 was approximately twice as large as that of panel No. 3. A greater degree of prestressing on the 7/8-in. rods would have provided greater stiffness to this panel.

(5) Panel No. 5

An examination of the load curve for this panel (Fig. 3) shows that the deflection for unit loads up to 50 lb. per sq. ft. was greater than that of the other panels. This panel was assembled without mortared joints, using machine-ground units. Some slight irregularities evidently prevented complete uniform contact between the units. As the loads increased, complete bearing was soon established (shown by the curves in Fig. 3). Between equivalent unit loads from 50 to 125 lb. per sq. ft., this panel demonstrated greater proportional rigidity than all of the other panels tested.

A comparison of this panel with No. 2 shows that increased loads and lower deflections may be obtained by using machine-ground units. Although the measured deflections were relatively small, they were approximately 10% greater for the quarter-point loading than the calculated deflections for a uniformly distributed load.

IX. Conclusions

Prefabricated ceramic members utilizing prestressed steel reinforcing rods have a logical position in commercial construction. In addition to the coordination of physical properties of the various materials, their economies are extremely important. The elimination of forms obtained by this development provides definite saving in time and material, and it eliminates a fire hazard from wood forms during construction.

A maximum clear span of 16 ft. was determined for the 6-in. floor thickness (Fig. 4). For greater spans that require increased floor thicknesses, an 8- or 9-in. width of beam is being considered. An auxiliary unit of this width may also be required in all unit sizes in order to stagger adjacent panels or to provide a closure beam when less than a full width is required.

The cement topping is not required with this system because the units are designed with a heavy upper shell to resist the compressive forces at the top of the panel. When the cement topping is used as a wearing surface, the additional strength which is obtained may be included in the safe working load design, provided the topping is 1 in. or greater in thickness.

For certain types of finished floors or wearing surfaces, only a thin leveling course of cement grout or asphaltcrete is required. Standard wood floors may also be used with this system by placing wood sleepers in a cinder concrete fill in the customary manner.

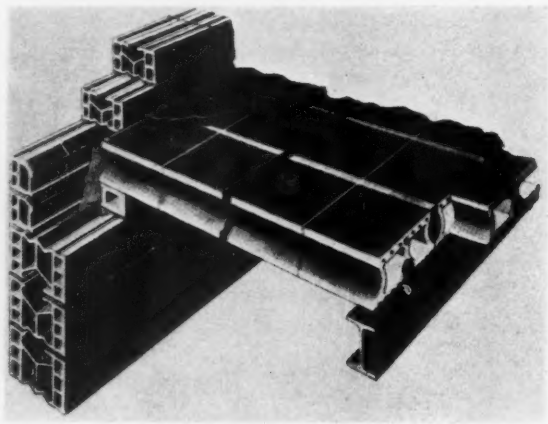

FIG. 4.—Clayspan floor.

Additional advantages are apparent with the use of high-yield steel. The effect of this will be studied in future tests; it is recognized, however, that many engineers and those responsible for building codes in particular are quite reactionary. Complete test information officially reported by recognized testing agencies is required to eliminate this opposition.

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EXPERIMENTAL STUDY OF INHIBITORY EFFECTS OF ALUMINUM COMPOUNDS IN SILICOSIS*

By Leroy U. Gardner, Morris Dworski and Anthony B. Delahant

Abstract

Experimental tests are described, in which vitrified sagger clay containing 50% of free silica was used. No silicotic reaction occurred in guinea pigs within twelve months. Previous experiments on animals, in which a hydroxide of aluminum was used, demonstrated that it, like the metal itself, afforded good protection against the action of silica. Whether the protection in the case of the sagger clay was due to the aluminum in the mullite or to other mechanisms could not be established. The free silica content of a dust is not necessarily a reliable index of its capacity to cause silicosis, and there is need to investigate the physiological effects of many mixtures of aluminum and free silica-containing minerals in use in the ceramic industry.

I. Introduction

The writer had been investigating the potentialities of aluminum hydroxide as an inhibitor of silica for some months when Denny, Robson, and Irwin announced their discovery that the use of metallic aluminum would prevent silicosis in rabbits. As it seemed probable that both of these agents would have a similar action and that quartz ultimately would be affected in the same manner within the body, the original program was continued. The conclusions of this laboratory in general confirm those of the Canadian investigators.

The results of one test that was recently completed will be described. This test indicates the presence of a protector substance in a vitrified, refractory clay of high free silica content. This material, previously fired for an undetermined number of times in a ceramic kiln, was used for bedding abrasive wheels in saggers when they were fired.

This example of protective action, which may or may not be due to the effect of associated aluminum in the clay, is interesting to ceramists for two reasons, (1) because it indicates that sagger dust per se is not necessarily dangerous to health and (2) because it illustrates a fallacy on which some of the industrial codes are based, namely, that only the free silica content of a dust defines its capacity to produce silicotic, nodular fibrosis.

II. Conclusions from Tests on the Inhibition of Silicosis

The experiments with animals on the inhibition of silicosis involved the injection and inhalation of very pure, fine quartz dust. At the same time or at various intervals thereafter, dilute suspensions of aluminum hydroxide were introduced by different pathways.

All of the necessary experiments have not been completed, but enough have been done to warrant the following conclusions: (1) In normal animals, aluminum hydroxide injected by various pathways is ingested by phagocytic cells and retained for prolonged periods of time. (2) The stored hydroxide seems to have little influence on the health of the normal animals. Whether it will affect natural resistance to superimposed infection awaits demonstration. (3) The injection of quartz particles in the same suspension with the aluminum hydroxide has no more effect on the tissues than the hydroxide alone. (4) When suspensions of quartz particles and aluminum hydroxide are injected independently, silicotic reaction is likewise inhibited, provided the pathways of introduction are such that the two materials are deposited in effective concentrations within the same organ. (5) When aluminum hydroxide is introduced after the quartz, silicotic reaction is checked at the stage already established at that time and no further progression ensues. (6) The silicotic lesions themselves heal and all evidences of fresh injury to the cells in the surrounding tissues disappear. (7) The retrogression and disappearance of pre-established silicotic nodules have not been observed.

The assay of the physiological activity of the vitrified sagger clay was prompted by a desire to discover whether the aluminum in this material was in such form that it would protect animals against the action of the associated free silica.

An analysis by a combination of chemical, petrographic, and X-ray diffraction methods demonstrated the following composition:

Free silica		50%
Quartz	15	
Cristobalite	15	
Tridymite	20	
Glass		30
Mullite		20
		100%

A petrographic examination of the unground material showed unaltered quartz grains that were readily identified. The remainder consisted of amorphous masses of a semiopaque substance whose component elements could not be identified. It is assumed from the X-ray patterns that they consisted of an intimate mixture of minute particles of cristobalite, tridymite, and mullite with glass. Previous experiments from this laboratory[1] have demon-

*Presented at the Forty-Third Annual Meeting, The American Ceramic Society, Baltimore, Md., April 2, 1941 (Materials and Equipment Division). Received April 3, 1941.

[1] L. U. Gardner, "Etiology of Pneumoconiosis," *Jour. Amer. Med. Assn.*, **111**, 1925–36 (Nov. 19, 1938).

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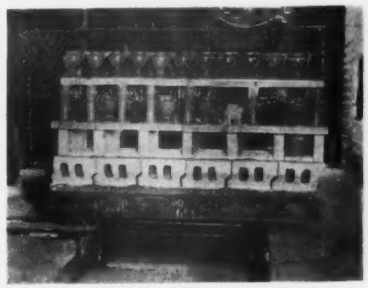

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strated that cristobalite and tridymite are just as active as quartz in provoking tissue reactions of silicotic type. The assumption may therefore be made that 50% of the components of this material belong in the category of excitants of silicosis.

A representative sample of this fine material was reground in an agate mortar until all of the particles were 10 microns or less in diameter. A 10% suspension by weight was made up in physiological salt solution and sterilized by steam at low pressure. A series of guinea pigs was injected intraperitoneally, the dose for each being 200 mg. At intervals of 1, 4, 8, and 12 months thereafter, members of the group were sacrificed.

At autopsy, their peritoneal surfaces were found to be studded with the usual soft, flattened, yellowish white-to-brown plaques ordinarily seen after the injection of inert mineral particles of this size. None of these plaques exceeded 10 mm. in any diameter, and their thickness was never more than 2 mm. The picture remained the same in the last animal as it was in the first of the series. Control guinea pigs similarly injected with 100 mg. of pure quartz particles (the quantity of free silica in this mixture) regularly have shown much larger nodules, which are hard in consistency and which undergo a progressive increase in size and density over a year's time.

Microscopic sections of the nodules of the test series revealed cellular changes indicative of an inert type of response. The reaction never progressed beyond the stage of phagocytosis throughout the period of observation. There was neither fibrosis nor hyaline degeneration of the connective tissue which characterize silicotic reactions in the peritoneal cavity of the guinea pigs.

Miller and Sayers,[2] who introduced this technique of animal testing, would classify the reaction as "inert." They interpret such effects to indicate that the excitant mineral would produce an interstitial fibrosis when it is inhaled into the lungs. Presumably inhalation of sufficient quantities would cause a more or less low grade of inflammatory reaction. The writers, however, do not agree that such responses constitute a *fibrosis* or with the implication that they are associated with more or less disability. However the observed tissue changes are classified, it must be obvious that their character and extent are in no way compatible with the quantity of free silica injected.

[2] J. W. Miller and R. R. Sayers, "Physiological Response of the Peritoneal Tissue to Dusts Introduced as Foreign Bodies," *U. S. Pub. Health Repts.*, **49**, 80–89 (Jan. 19, 1934).

III. Protection Against Free Silica

The question of whether the observed evidences of protection against the free silica were caused by the aluminum in the mixture cannot be answered from the available data. All of the clay appeared to have been transformed into mullite in the process of calcination. It is hard to believe that this resistant compound would be attacked by the body to liberate any of the aluminum in a form capable of coating free silica particles. But on the other hand, it was once hard for everyone to accept the hypothesis that quartz could be so attacked. Proof that mullite might act as an inhibitor could be obtained by injecting a mixture of this substance produced in the absence of free silica and pure quartz. This test will be made soon.

The other explanation that suggests itself is the possibility of a protective coating of resistant glass applied to the surface of the free silica grains during the process of calcination. The quartz surfaces seemed to be clean on visual inspection, and it was only assumed that the other forms of free silica might be coated. The greatest objection to such an explanation is the fact that the material was reground and that unaltered surfaces of free silica would necessarily be exposed during this process. If such were the case, there should have been greater evidence of silicotic tissue changes.

IV. Conclusions

These experiments have confirmed the findings of Denny, Robson, and Irwin that it is possible to prevent the development of silicosis with compounds of aluminum. The results suggest that alumina, at least from some of the clay minerals used in the ceramic industries, may inhibit the toxic action of flint and quartz. If it were not so, the incidence of silicosis in the potteries and allied industries should be greater than it is. A systematic study of the physiological action of dust-producing minerals in the ceramic industries should yield information of scientific and practical importance. Such a study would (1) demonstrate whether clays themselves are capable of serious damage to the lung, (2) indicate the particular minerals most effective in neutralizing toxic free silica, and (3) point to the processes which need special attention in a program of dust prevention.

Saranac Lake, New York

INDUSTRIAL HEALTH SERVICE FOR THE SMALL PLANT IN THE CERAMIC INDUSTRY*

By Huntington Williams, Wilmer H. Schulze, and John M. McDonald†

Abstract

The potential hazards to be expected in the operation of a plant in the ceramic industry are described, provision for medical service is discussed and the availability of the industrial hygiene service in the state or local health department is explained.

I. Introduction

The chief objectives of a health service in any industrial plant are (1) the selection of proper men for the respective jobs and (2) the provision of a working environment that will not endanger the health or safety of the workers. These are of paramount importance at all times, and they are particularly necessary during the present national emergency when so much depends on keeping industrial output at a maximum. The ceramic industry has an obligation to fulfill in national defense, and this, over and above other natural considerations, requires the conservation of the health of all workers in its manufacturing plants.

(1) Industrial Hazards

The large variety of products included in the ceramic industry offers possible exposures to working environments which may have an adverse effect on the health and productive capacity of the employee. Dusts containing silica, silicates, or other inorganic chemicals; such gases as carbon dioxide, carbon monoxide, hydrogen fluoride, and sulfur dioxide; and lead, chromium, alkalis, and other skin irritants are among the more common materials that may be encountered in harmful concentrations. High temperatures and temperature variations may also have considerable significance in relation to the employee's health. With the present speed-up in industrial output, fatigue should not be overlooked, and other factors, which are sometimes neglected, include lighting, ventilation, adequate toilet and sanitary facilities, and the proper protection of the drinking water from contamination.

II. Industrial Health Service in Small Plants

An industrial health service includes medical and engineering practices. Although such services are available in many of the larger industries, it is usually beyond the reach of the smaller plants to supply them on a full-time basis. Consideration therefore will be given to what such services should cover and how they may be obtained by plants that have 200 or fewer employees.

(1) Engineering Studies

Engineering studies consist of investigations throughout the entire plant to detect any conditions which might endanger the health or safety of the industrial population. Studies are made of the physical environment of each workroom and of the operations and materials handled in each occupation in the entire plant. Where such occupational hazards as exposure to lead or silica dusts are encountered, they are noted for further detailed study. Attention is given to protective measures in use against hazardous materials, and further studies are made to determine their efficiency if this seems to be advisable. A close scrutiny is given to possible accident hazards and to the use of effective guards where they are needed.

Adequate lighting, without glare, is easily determined and is important in accident prevention as well as in the quality and quantity of production. General ventilation and local exhaust ventilation, if properly used, are essential needs to provide comfortable workroom temperatures and to remove harmful materials from the breathing zone of the employees. Personal facilities, such as adequate and properly maintained locker-rooms, toilets, washing and bathing facilities, and lunchrooms are important in every complete industrial health program. A safe, potable drinking-water supply, free from any cross connections and made available by sanitary types of drinking fountains conveniently located, is an essential in every plant. Finally, good housekeeping throughout the entire plant plays an important role in every health and safety program.

(2) Medical Studies

Occupational diseases are preventible, and the industrial hygiene services of the physician and the engineer are planned to assist the management in preventing their occurrence. Where the possibility of exposure to toxic substances exists, it is essential to know whether the conditions under which the employees work may lead to illness. Visual inspection is rarely sufficient to arrive at a decision. Consider, for instance, exposure to lead in the form of dust. The inhalation of more than 1.5 mg. during the ordinary work day for a period of time is likely to cause lead poisoning, but this amount of lead in the form of a fine dust would be entirely invisible to the naked eye. Carbon monoxide is a colorless and odorless gas, so that its presence in

*Presented at the Forty-Third Annual Meeting, The American Ceramic Society, Baltimore, Md., April 2, 1941 (Materials and Equipment Division). Received April 3, 1941.

†Respectively, Commissioner of Health, Director of Sanitary Section, and Director of Bureau of Occupational Diseases, Baltimore City Health Department.

the workroom air cannot be detected by the common methods of sight or smell.

III. Methods to Prevent Occupational Diseases

Occupational diseases may be prevented by two important procedures. A careful study should first be made to determine the extent of the exposure of the workers to toxic substances. This frequently involves the collection of representative samples of the air in the breathing zone of the employee and then an analysis of the samples in the chemical laboratory. If the concentrations in the workroom air are found to be above the limits of safety, the installation of adequate protective measures is needed.

The second, and equally important procedure, calls for medical examinations of these workers at regular intervals to detect any signs or symptoms characteristic of the action of the toxic material when it is taken into the system in harmful amounts.

IV. Studies in Baltimore Plants

A few examples may be of interest from our City Health Department experience in Baltimore.

In a ceramic plant in this city, workers employed in dumping raw materials into batch containers on a platform scale below the floor level were exposed to a dust high in free silica content. It was impracticable to expect these employees to wear respirators throughout the day, although it was demonstrated by actual study that the dust concentrations were as high as 86 million particles per cubic foot of air. An ingenious engineer in the plant designed a duct-collecting system for this operation at a cost of less than $100, and it was placed in service. A study of the dust concentration in the room after the installation of this equipment showed a reduction to a little over 2 million particles per cu. ft. of air, which is well within the limits of safety.

Studies made in another plant revealed exposures to high concentrations of a silica-containing dust while unloading raw materials and in batch-mixing operations. Medical examinations, including X-ray pictures of the chests of the workers, indicated a possibility of injury to the health of several employees. Steps were taken to change the method of handling the raw materials, and an adequate dust-collecting system was installed in the batch-mixing room. Subsequent studies of the dust concentrations showed a satisfactory control of exposures.

Where personal protective equipment must be relied on, frequent inspections of its efficiency should be made. In a third Baltimore plant it was necessary for a worker to wear a positive-pressure air helmet to guard against the inhalation of a lead-containing dust during a blasting operation. The helmet did not fit properly and was so defective that dust accumulations were visible on the employee's face when the helmet was removed. This man developed lead poisoning, and an analysis of the air in the cabinet in which he worked showed high concentrations of lead in the dusty atmosphere. Medical examinations of the man at short and regular intervals together with better supervision would have prevented this case of lead poisoning.

V. Medical Part of Hygiene Program

When the physician finds the early signs of an occupational disease, it is his duty to bring the matter to the attention of the management so that physician and engineer may work together to reduce or eliminate the causative hazard and thereby prevent further cases of the disease.

The medical portion of the industrial hygiene program is based on physical examinations of the employees of the plant. Before he begins to work, each employee should be examined by a physician who is familiar with the individual occupations in the plant so that each employee may be placed in a job well within his mental and physical capacity. Proper job placement conduces to the production of more and better work and reduces lost time, accidents, and labor turnover. The nature of the pre-employment physical examination will vary from plant to plant and even from job to job. The ground to be covered is a matter to be determined by the examining physician. It is suggested, however, that this examination should include an STS (a serological test for syphilis). Syphilitic applicants should not be rejected merely on the basis of a positive STS if they are otherwise physically fit and if they are willing to undergo adequate treatment, but it is strongly advised that their treatment be closely followed up. This essentially is the basis of the so-called Baltimore Plan for Syphilis Control in Industry.

A regular periodic examination of the employees should be done every year or two. In special exposures to certain substances, such as lead for example, a partial examination may be required at intervals of a month or two. By means of periodic examinations, the physician is able to detect the earliest signs of disease, whether it is occupational or nonoccupational in origin and so may begin early treatment with correspondingly good hopes for an early cure. Lost time is reduced or perhaps avoided.

In addition to the routine examinations suggested, it is a good idea to have every employee checked over on returning from an absence whatever its cause may have been. Workers thus may be prevented from returning to work while they are unfit, and this may have an effect on the reduction of accidents. Physical examinations have their benefits for employees as well as for employers. The employees are protected from accidents, resulting from a physical defect in a fellow employee, and the funds of the sick benefit association are protected by the exclusion of persons in poor health.

Because disability from industrial accidents is now compensable in all but one state, practically all plants keep some sort of accident records, but it is not common to find that records of other types of absenteeism are available. For example, the average lost time among industrial employees in the United States is nine days per man per year. One half of this lost time is caused by colds, influenza, bronchitis, or some such respiratory ailment. Where men are losing more than nine days per year or where there is an exorbitant loss of time from one special complaint, the cause for such absenteeism should be sought out and removed.

VI. Suggestions for Medical Service in Small Plants

A small plant, obviously, may often be unable to afford its own physician or nurse on a full-time basis. A practical solution of this problem is for a group of such plants to get together and engage a doctor and nurse who know industrial hygiene and who will devote their entire time to these plants. A part of their time may be taken up by surgical dressings. The physician should be required to go through the entire plant at irregular intervals and at varying times of day so that he will become familiar with all of the processes and with all of the variations in working conditions. He should report directly to the management and not to an intermediary subordinate. He may best make all physical examinations in his own private office and will doubtless refer all cases of nonoccupational disease to the employee's private physician.

Another method for small plants is to secure nursing service through the local Visiting Nurse Association if there is one. Such associations are often willing and able to supply part time or hourly nursing care for industrial plants. In any case, where part-time nursing is employed, it is always well to arrange to have the services of the same nurse for any given plant.

Where full-time nursing and medical services are impracticable, it is important to have at least one employee trained in giving first aid so that an injured employee will get competent treatment promptly. Courses in first aid are available in many centers under the direction of the local Red Cross or the local branch of the Safety Council, and employers are urged to have at least one man well trained in these principles.

The management, furthermore, should be willing and anxious to make use of available consultation services in industrial hygiene from disinterested governmental agencies. These industrial hygiene divisions, which may be found in many state health departments or occasionally in a state labor department or a city health department, have physicians and engineers who are familiar with the plant conditions that cause occupational diseases and the various ways and means to overcome such hazards, and their services may be had upon request. Even the smallest plant may thus secure the friendly advice and guidance of men trained to investigate and correct conditions causing disease.

In states where such health department services have not yet been set up, assistance may be obtained from the Division of Industrial Hygiene in the U. S. Public Health Service in Washington. Many casualty insurance companies have their own laboratories and engineering staffs for use in the control of industrial hazards. The National Safety Council has much valuable material applicable to such hazards. The National Association of Manufacturers is making an effort to assist its members to deal with the conditions causing occupational diseases through its Committee on Healthful Working Conditions, and the Air Hygiene Foundation in Pittsburgh is well equipped to furnish engineering services and technical advice to its members. One or more of these sources is available to practically any industrial plant.

VII. Summary

An outline has been given for securing and applying industrial hygiene service to the small plant in the ceramic industry. The use of engineering and medical principles to conserve and promote the health of the employes is also outlined.

Baltimore City Health Department
Baltimore, Maryland

DISCUSSION ON "SYMBOLISM IN CHINESE PORCELAIN DECORATION"*

By Lawrence E. Barringer

Dr. Chen has given an interesting account of a unique feature of oriental ceramic art, namely, its symbolism. One of the pleasures gained from Chinese porcelain decoration is its symbolic meaning.

The subject is complicated, however, and to assist the interested ceramist in determining the meaning of Chinese symbols, it would be splendid if someone (perhaps a student in one of the ceramic art schools) would arrange a tabulation for ready reference, as Meyer[1] has done with the significance ascribed by the Chinese to various colors as follows:

Color	Point of compass	Season	Element	Planet	Metal
Black	North	Winter	Water	Mercury	Iron
Green	East	Spring	Wood	Jupiter	Lead
Red	South	Summer	Fire	Mars	Copper
White	West	Autumn	Metal	Venus	Silver
Yellow	Equator		Earth	Saturn	Gold

This varied meaning of colors applies also to other symbols, such as birds, in which the symbolism is still more intricate. Dr. Chen says there are 360 different Chinese birds according to Chinese Book of Rites. Perhaps not all of these are used as symbols but there are enough to form a large group. Birds, moreover, in combination with certain flowers apparently have other meanings than the birds alone. Dr. Chen speaks of the magpie with the plum flower (prominent person) and the thrush with the bamboo (one humble and fine in character); the prunus or

* Paper by Chao Ming Chen, published in *The Bulletin*, pp. 196–207, June, 1941.

Discussion received May 27, 1941.

[1] C. Meyer, *Ciba Review* (Basle, Switzerland), No. 37, January, 1941.

plum flower alone signifies winter and the bamboo alone, humbleness. Several birds or animals may mean the same thing, for instance, the stork, crane, and butterfly each represents longevity.

The bat appears to be quite a bird in Chinese art; alone, it represents happiness; five bats indicate five kinds of happiness (perhaps to correspond to the five senses distinguished by Aristotle), but the meaning of the hundred bats mentioned by Dr. Chen is difficult to conjecture and even he ventures no interpretation.

The following excerpts concerning oriental symbolism are taken from an article entitled "Symbolism in the Oriental Carpet."[2]

"The Oriental conception of a Universal Spirit, which is infinite and eternal and which pervades all the multifarious forms of Nature, can only find expression in symbols and similies. Nothing lives of itself or for itself alone—of importance is only what the things mean for a world of spiritual values....."

"This language is not identical for the whole of the Orient. The symbolic value of the colors varies with countries, religions, and tribes.

"Yellow, the sacred color of the Chinese, stands for summer, sun, resurrection, and for the imperial power."...

"Every plant had its own symbolic significance. Autumn, winter, spring, and summer were expressed by chrysanthemums, narcissi, peach, and lotus blossoms."...

"Animals also have their symbolic values. In China, the dragon stands for Heaven and for the emperor; the bat, for happiness; the butterfly, for longevity; and the scorpion, for poison."

"The four elements had certain geometrical expressions, which, however, we are frequently unable to recognize. The symbolic significance of the cloud-band, which expressed now rain, wind, or clouds, now the rolling thunder, made it very widely used. The Chinese 'Chi,' an undulating mass of cloud, also frequently found on Persian and Caucasian carpets, was a sign of immortality; the Mongols regarded it as the Great Bear, where the lord of the universe resided."

These statements are presented here because they are not in strict agreement with some of Dr. Chen's explanations. The question is thus raised as to whether or not Chinese symbolism differed somewhat with different categories of articles, such as carpets and pottery.

A tabulation would be helpful and interesting to those interested in ceramic art and I am sure that whoever undertakes it will find the task a pleasant one.

General Electric Company
Schenectady, N. Y.

[2] *Ciba Review*, No. 15, November, 1938.

CERAMIC HISTORY

THE PITTSBURGH PLATE GLASS COMPANY*

Established in 1880

The character and history of the Pittsburgh Plate Glass Company can, like those of most other successful organizations, be interpreted in terms of its people. Physical growth, financial successes or depressions, reputation among employees and customers are all the result of the type of people who comprise the Company.

A few dominant and pioneering spirits usually initiate the hazardous undertaking of beginning a new business unknown in the country before, and their drive, character, and outlook become so firmly infused throughout their small group of associates that a company for many years after its founding bears the stamp and outlook of its originators, whether the growth is slow or rapid.

In this respect, the Pittsburgh Plate Glass Company has had an unusual history, guided by men of high purpose and sound judgment. Today it stands unique in sturdiness, management, and in the close cooperation of its various and far-flung autonomous parts.

Up to 1880, all who had attempted to make plate glass in this country had lost money and had discontinued manufacture. Business men and investors looked askance at such undertakings. They had good reason, for these futile efforts were made by men handicapped by inefficient equipment, lack of skilled labor, and inexpert technical management. All of the latest machinery was built abroad; the process of plate-glass making was an intricate one, and experienced workmen had to be imported from Belgium, France, or England.

The idea, furthermore, was rapidly crystallizing that plate glass could not be manufactured profitably on a small scale. This fact meant that a business must be heavily capitalized and must be equipped with costly apparatus for large-scale operation, and all this in the face of keen foreign competition. As the standard of living was low compared to what is now taken for granted, prices had to be very low in relation to cost; otherwise there would be no market.

At least two men in this country were not afraid of such tremendous obstacles. The team fitted perfectly. One was an adventurer, a riverboat captain who had traveled widely and had become convinced that money was to be made in plate glass if money could be had to build and operate plants. He tried it—and failed. But Captain John B. Ford[1] was no man to quit. He succeeded in persuasion where he failed in successful execution.

The man who listened, became convinced, and entered the partnership was a shrewd Scot, who agreed that the

* From "The Pittsburgh Plate Glass Company and the People Who Made It Possible," *Pittsburgh People*, **1** [1] 7–9 (July, 1940).

[1] For story of Captain Ford, see *Bull. Amer. Ceram. Soc.*, **18** [7] 262–67 (1939).

plate-glass business, if well-managed financially, could be made to pay fair returns. These two intrepid business pioneers of the early eighties—one a tough river captain, the other a successful and determined officer of the Pennsylvania Railroad, John Pitcairn, gave the new Company the somewhat fanciful name of the New York City Plate Glass Company. The first plant was built in 1881 at Creighton, Pennsylvania, near the source of plentiful natural gas and sand. This indeed was the first plant in the United States that uninterruptedly produced plate glass on a successful basis. A modern plant on this site is still known as Works No. 1.

W. L. Clause, President, 1905–1916

On August 17, 1883, the corporate name was changed to the Pittsburgh Plate Glass Company. But after this Creighton plant was successfully established and in operation, other companies, lured by the hope of profits, were organized. Natural gas became available in the Middle West, and plate-glass manufacture became something of a boom, so much so that by 1893 there were twelve plants in the business. Rapidly increased production caused keen competition and inevitable overproduction among domestic producers.

A consolidation soon occurred whereby the Pittsburgh Plate Glass Company acquired plate-glass factories at Ford City, Charleroi, and Duquesne, Pennsylvania; Elwood and Kokomo, Indiana; and Crystal City, Missouri.

In 1895, the Company was reorganized, the capital stock was increased, Edward Ford (son of John B.) was made president, and the Company became the organization as it is known today. It was then operating nine plate-glass factories and two coal mines.

Warehouse Plan

About this time, an idea common today but considered radical in 1896 was put into effect, that of operating the Company's own distributing warehouses. W. L. Clause, who entered the Company in 1895, was largely responsible for this innovation. It was a policy that guaranteed outlets for Pittsburgh products, in addition to regular dealer channels. The practice continues in effect at the present time.

Charles W. Brown, President, 1916–1928

The reorganization and change in the distribution system, however, led to a separation of the Ford and Pitcairn interests. In 1897, Mr. Pitcairn was elected president, a position he held until 1905 (afterward he was Board chairman until 1916), and the Fords, always eager to build new glass plants, withdrew to begin a competitive business in Toledo, Ohio.

Management

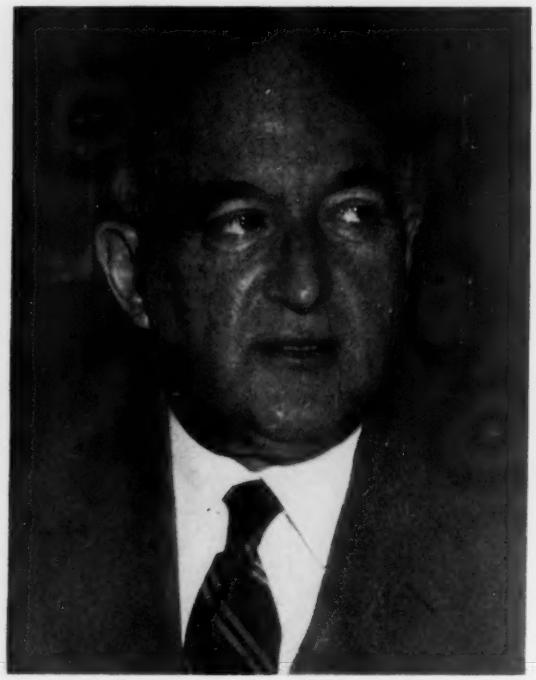
The first president of the original company was Edward Ford, son of one of the founders.

EDITOR'S NOTE

Robert L. Clause was elected president of the Pittsburgh Plate Glass Company in March, 1941, to succeed H. S. Wherrett, who now holds the newly created position of vice-chairman of the Board. Mr. Clause was previously executive vice-president and first became associated with the Company as a draftsman in 1914.

In 1897, after the reorganization, John Pitcairn was elected president, and in 1898 he became chairman of the Board of Directors as well.

W. L. Clause, former secretary of the Diamond Plate Glass Company, which later became part of the Pittsburgh Plate Glass Company, became president in 1905. He became chairman of the Board upon the death of Mr. Pitcairn in 1916 and was succeeded by Captain Charles W. Brown, who had been vice-president since 1906. Mr. Brown was a one-time New England sea captain, but he forsook his original calling in the early eighties and established a wholesale glass company in Minneapolis. He later joined the Pittsburgh Plate Glass Company and was elected secretary in 1898. He served as president for twelve years.



H. S. Wherrett, president, 1928–1941

Robert L. Clause, president, 1941–

Clarence M. Brown, no relation to Captain Brown, who for many years was associate and legal advisor to Mr. Pitcairn, entered the Company during its period of development as vice-president and general counsel. He is at present chairman of the Board of Directors.

H. S. Wherrett has been president of the Company for the past twelve years. A member of the organization for forty-eight years, he is, in point of service, one of the oldest employees. Beginning as office boy to Mr. Clause, he has come to his present position the hard way, through years of work, patience, and merit.

Fortune once said of him: "He carries on the conservative policies initiated by his predecessors. He, like them, is surrounded by a group of executives who have gained their experience within the Company and its subsidiaries. As the founders of Pittsburgh Plate entrusted the responsibility of conducting manufacturing operations and managing the distributing warehouses to men with long records of service—so does he. Almost without exception, the present officers, directors, factory superintendents, and department heads have worked their way up from minor positions. They devote their entire attention to Pittsburgh Plate and have no other business interests."

Pittsburgh Plate Glass Company Today

The present organization includes twenty-five factories, seventy-eight warehouses, and thirty-four stores and employs more than 18,000 people.

He Succeeds Who Determines So to Do

It Is Only by Communication with Others That Knowledge Is Acquired; Membership in The American Ceramic Society Is Opportunity for This Achievement

ACTIVITIES OF THE SOCIETY

ENAMEL DIVISION BUSINESS MEETING

The annual business meeting of the Enamel Division was held on April 2, 1941, at the Lord Baltimore Hotel, Baltimore, Md. The meeting convened at 1:15 P.M., with James D. Tetrick presiding.

Clark Hutchison read the report of the Standards Committee.

CHAIRMAN TETRICK: I would like to hear some comment on this report.

F. M. ROOT: Mr. Tetrick, I move we recommend to the Standards Committee of The American Ceramic Society that these two tests be adopted.

CHAIRMAN TETRICK: Mr. Root has made a motion that the two tests suggested by Mr. Hutchison, namely, the reflectance test and the acid-resistant test, be recommended to The Society for adoption as standard tests. Is there a second to the motion?

B. T. SWEELY: I will second that motion. I believe that these tests have been worked out by the Institute in close cooperation with a number of men who are vitally interested in this Division. It would seem almost foolhardy to undertake to revise or to improve the tests after the experience we had in getting this work done in the Institute. I am heartily in favor of seeing this recommendation go up to our Standards Committee of The Society.

CHAIRMAN TETRICK: It has been moved and seconded that the reflectance test and the acid-resistant test of the P.E.I. be recommended to The American Ceramic Society for adoption as standard tests. All in favor say aye. Opposed. The motion is carried.

CHAIRMAN TETRICK: Dr. Spencer-Strong has a few remarks to make on the new rules.

G. H. SPENCER-STRONG: The rules which were published in the August issue of *The Bulletin* were accepted practically unanimously by this Division, and there was a surprisingly large vote for which the Committee thanks you.

According to the rules, after ninety days the ballot was counted and certified to the change. This was done and we are now operating under the new rules, and the new officers, who will take office at the end of tomorrow's meeting, will function in accordance with the new rules rather than the old.

Chairman Tetrick read the report of H. D. Carter, Chairman of the Editorial Committee.

CHAIRMAN TETRICK: I think an analysis of this report shows that the Editorial Committee has done excellent work during the past year. In some previous years we had a great deal of delay in getting our papers into print, and I think the work of our Editorial Committee this year cannot be too highly commended.

At this time I would like to announce the results of the Enamel Division ballot.

R. L. Fellows was elected chairman. Under the new rules, we now have a vice-chairman, who also takes over the function of chairman of the Papers and Program Committee. Karl Kautz was elected to this office. D. G. Bennett was elected secretary. James D. Tetrick and W. H. Pfeiffer were elected councillors. George Tuttle was named to Nominating Committee A, and E. C. Aydelott was named to Nominating Committee B.

There is one other bit of business. Yesterday afternoon the matter of an honorarium to Morris Schrero for his work on the Enamel Bibliography was brought up, and Dr. Spencer-Strong will present a motion at this time.

DR. SPENCER-STRONG: Mr. Chairman, in view of the fact that Mr. Schrero has spent a tremendous amount of his own personal time on this Bibliography, your Bibliography Committee feels, as does the Executive Committee of the Division, that we should recompense Mr. Schrero somewhat to show our appreciation of his efforts. This Division naturally hopes to print other bibliographies, and we feel that a little bread cast upon the water at this time may return in five or ten years in the shape of another excellent effort from the same library.

I therefore move that this Division pay Mr. Schrero $100, to go with a suitable letter from our secretary stating our thanks for his valuable cooperation and effort in this matter.

The motion was seconded by J. E. Rosenberg.

CHAIRMAN TETRICK: The motion has been made and seconded that we award Mr. Schrero an honorarium of $100 and send him an appropriate letter of thanks for his splendid work on the Enamel Bibliography. All in favor of this motion please say aye. Opposed. The motion is carried.

Is there any other business that anyone cares to bring up at this time?

REXFORD NEWCOMB, JR.: Mr. Chairman, a few moments ago Mr. Root made a motion, which was approved, that the two standards of P.E.I. be recommended to the Standards Committee of The Society. No disposition, however, was made of the remainder of the report of the Standardization Committee, and I think a motion would be entirely in order under which the Enamel Division would approve and accept the entire report, which action would then instruct the chairman of the Committee to contact the P.E.I. committee and work in conjunction with them. I so move.

The motion was seconded by Mr. Root.

CHAIRMAN TETRICK: The motion has been made and seconded that the entire report of the Standards Committee be accepted and the chairman of our Committee work more closely with the chairman of the P.E.I. Committee. All in favor of this motion please say aye. Opposed. The motion is carried.

Upon motion regularly made, seconded, and carried the meeting adjourned at 1:35 P.M.

INSTITUTE OF CERAMIC ENGINEERS

Executive Committee

President: E. H. FRITZ, Westinghouse Electric & Mfg. Co., Derry, Pa.
Vice-President: H. M. KRANER, Bethlehem Steel Co., Bethlehem, Pa.
Secretary: H. B. DUBOIS, Consolidated Feldspar Corp., Trenton, N. J.
Past-President and Trustee Representative: H. G. WOLFRAM, Porcelain Enamel & Mfg. Co., Baltimore, Md.
Past-President: A. F. GREAVES-WALKER, Dept. of Ceramic Engineering, Univ. of North Carolina, Raleigh, N. C.*

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Member Grade

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C. J. KOENIG, 3007 Neil Ave., Columbus, Ohio.
PERRY D. HELSER, 394 S. Lexington Ave., White Plains, N. Y.
PHILIP DRESSLER, Swindell-Dressler Corp., Box 1888, Pittsburgh, Pa.
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M. C. BOOZE, Charles Taylor Sons Co., Cincinnati, Ohio.
F. H. NORTON, Massachusetts Institute of Technology, Cambridge, Mass.
C. E. BALES, Ironton Fire Brick Co., Ironton, Ohio.

Associate Member Grade

E. C. AYDELOTT, Murray Corp., 7700 Russell St., Detroit, Mich.
H. D. CALLAHAN, U. S. Quarry Tile Co., East Sparta, Ohio.
E. R. CRANDALL, 30 Pearl Hill, Milford, Conn.
R. C. HUTCHISON, R. D. 1, Easton Ave., Bethlehem, Pa.
E. W. KNAPP, New England Brick Co., 22 Beacon St., Boston, Mass.
SIDNEY W. MCCANN, Pfaudler Co., Rochester, N. Y.
E. B. MERRY, JR., Merry Brothers Brick & Tile Co., 415 Masonic Bldg., Augusta, Ga.
WILLIAM F. MOONEY, 3905 Monterey Rd., Los Angeles, Calif.
JAMES L. SOMMERVILLE, Company A, 28th Battalion, Engineer Replacement Center, Ft. Leonard Wood, Mo.
HAROLD D. PRIOR, 1310 Vanderbilt Ave., Niagara Falls, N. Y.
EARL C. PETRIE, North American Refractories Co., National City Bank Bldg., Cleveland, Ohio.
ROBERT W. LIMES, Mellon Institute, Pittsburgh, Pa.
ROBERT S. GREEN, 1105 S. Jefferson St., Mexico, Mo.
J. T. ROBERTS, 2111 Grove Ave., Berwyn, Ill.
KENNETH E. SMITH, 6926 Willow St., New Orleans, La.
CECIL H. TURNER, 884 Chester Rd., Charleston, W. Va.
CARL H. ZWERMANN, Box 162, Robinson, Ill.

Junior Member Grade

ROBERT S. HAFF, JR., 19 Willard St., Hartford, Conn.

Advancements

Walter D. Ford, 72 W. Third Ave., Columbus, Ohio, and William Horak, Hartford-Empire Co., Hartford, Conn., have advanced in grade from associate members to members; Albert O. Knecht, Camden Pottery, Camden, N. J., has advanced in grade from junior member to associate member.

(For Joint Meeting announcement, see p. 296.)

NEW MEMBERS OF THE SOCIETY FOR JULY

Corporation

STANDARD PORCELAIN ENAMEL CO., Harry E. Johnson (voter), American and Luzerne Sts., Philadelphia, Pa.

Personal

ARMISTEAD, W. H., 240 Pine St., Corning, N. Y.; Corning Glass Works.
*ARRANDALE, ROY S., Thatcher Mfg. Co., 36–20 Vernon Blvd., Long Island City, N. Y.
BLISS, L. GANONG, 607 Custis Rd., Glenside, Pa.; sales engineer, Foote Mineral Co.
BRADLEY, C. A., JR., 10 W. Second St., Corning, N. Y.; Corning Glass Works.
DAGER, WILLIAM A., 505 Buttonwood St., Norristown, Pa.; E. J. Lavino & Co.
DAVIS, J. K., 248 Pine St., Corning, N. Y.; Corning Glass Works.
DEAKINS, LYNN, 702–703 Provident Bldg., Chattanooga, Tenn.; Peirson-Deakins Co.
DEVOE, C. F., 148 High Rd., Corning, N. Y.; Corning Glass Works.
DEWOLF, DANIEL, 32 E. First St., Corning, N. Y.; Corning Glass Works.
DORNAU, FRED F., 171–91 Wallabout St., Brooklyn, N. Y.; general superintendent, J. B. Slattery & Brothers.
ERICKSON, A. A., 295 Denison Parkway, Corning, N. Y.; Corning Glass Works.
FERGUSON, J. N., 219 Canisteo St., Corning, N. Y.; Corning Glass Works.
FLOWERS, E. B., 811 Drewry St., N.E., Atlanta, Ga.; enameling plant superintendent, Warren Co., Inc.
GEORGE, D'ARCY, 117 Haws Ave., Norristown, Pa.; E. J. Lavino & Co.
GRAY, W. T., 201 Kingsbury Ave., Corning, N. Y.; Corning Glass Works.
* LYONS, SANFORD C., 133 Lowell St., Arlington Heights, Mass.; technical director, Georgia Kaolin Co., Dry Branch, Ga.
MARTIN, F. W., 162 Cedar St., Corning, N. Y.; Corning Glass Works.
MORRISON, WALLACE S., 1293 N. Main St., Rockford, Ill.; vice-president and chief chemist, Illinois Water Treatment Co.
PIKE, ROBERT D., 342 S. Highland Ave., Pittsburgh, Pa.; consulting chemical engineer, Harbison-Walker Refractories Co.
PITTMAN, W. C., 820 Nebraska Ave., Cincinnati, Ohio; sales representative, Charles Taylor Sons Co.
PUNDERSON, L. E., 2248 Coventry Rd., Cleveland Heights, Ohio; special representative in vitreous enamel industry, J. B. Ford Sales Co.
RAMSAY, R. T., 204 E. Jacoby, Norristown, Pa.; E. J. Lavino & Co.
SAMUEL, DONALD G., 115 Haws Ave., Norristown, Pa.; E. J. Lavino & Co.
SEANOR, J. G., 2300 W. Tuscarawas St., Canton, Ohio; sales representative, Bonnot Co.
SHAW, LLOYD E., L. E. Shaw, Ltd., Halifax, Nova Scotia; president.
* SLICK, EDWIN E., U. S. Glass Co., Tiffin, Ohio.
STOOKEY, S. D., 316 E. Second, Corning, N. Y.; Corning Glass Works.
WEBSTER, HUGH B., Hulmeville, Pa.; salesman, Harshaw Chemical Co., Philadelphia, Pa.
WINAND, WILLIAM T., 901 McKewin Ave., Baltimore, Md.; general manager and secretary-treasurer, Baltimore Enamel & Novelty Co.

Student

Rutgers University: WILLIAM F. MCDEVIT.

* Indicates former member of The Society rejoining.

MEMBERSHIP WORKERS' RECORD

Corporation

O. O. Kenworthy	1

Personal

R. E. Birch	1	J. T. Littleton	10
G. H. Chambers	1	G. E. Seil	4
Donald Hagar	1	Office	12

Student

G. H. Brown	1	**Grand Total**	**31**

ROSTER CHANGES DURING JULY†

BESLEY, JOHN S., Box 89, Ashland, Wis. (East Liverpool, Ohio)
BREEZE, LEWIS K., 1358 E. 185th St., Cleveland, Ohio (Columbus, Ohio)
BUCHHOLZ, RUSSELL A., Washington Pine Apts., 5501 W. Washington Blvd., Chicago, Ill. (Pittsburgh, Pa.)
HAYNES, JACK C., 468 Seneca Parkway, Rochester, N. Y. (Trenton, N. J.)
KILLMAN, HENRY M., Y.M.C.A., Wilmington, Del. (Perth Amboy, N. J.)
KNECHT, ALBERT O., Camden Pottery, Camden, N. J. (Collingswood, N. J.)
MULLER, MAX M., 2027 Miles Rd., Route 3, Lapeer, Mich. (Highland Park, Mich.)
PETERSEN, FRED A., General Delivery, Gardner, Mass. (Frankfort, Ind.)
PHELPS, NELSON G., Ceramic Supply Co., Crooksville, Ohio (San Juan, Puerto Rico)
PRIEST, HARRY C., 3480 Durocher, Montreal, Quebec, Canada (Saskatoon, Saskatchewan, Canada)
PRIOR, HAROLD D., R.F.D. 1, Lewiston, N. Y. (Niagara Falls, N. Y.)
SIMON, A. G., Pickard, Inc., Antioch, Ill. (Chicago, Ill.)
STONE, ROBERT L., Dept. of Ceramic Engineering, University of North Carolina, Raleigh, N. C. (Alfred, N. Y.)
WALDSCHMIDT, MILTON H., 47th F. A., Fort Bragg, N. C. (Anderson, Ind.)

† Address in parentheses is former address.

Make This Society Stronger

If

Vocational Security Is Desired

By Active Participation in Meetings

By Working with Officers and Committees

By Offering Membership Privileges to Ceramic Persons and Corporations

Paid Membership Record

Date of Record	Members Paid		Deferred	Subscriptions	Monthly Sales	Total Circulation
	Personal	Corporation				
December 20, 1940	1995	260	25	574	220	3074
January 20, 1941	2007	262	27	594	220	3110
March 10, 1941	2023	257	26	620	220	3146
April 21, 1941	1794	247	47	563	220	2871
May 21, 1941	18 9	2- 9	47	580	220	2935
June 21, 1941	1875	249	45	584	220	2973
July 21, 1941	1898	251	46	587	220	3002

- The Roster Purge of Unpaid Members Last April Caused a Loss of 208 Personals and 10 Corporations.
- Renewals and New Members Secured since April Bring the Paid Personal Membership Roster to within 105 and the Paid Corporation Roster to within 6 of the March Record.
- There Were 13 New Paid Members and 10 Renewals This Past Month—23 in All.

CERAMIC CORPORATION SUPPORT IS NEEDED

EXCERPTS FROM THE CONSTITUTION, BY-LAWS, AND RULES

Article III (1) (e) Corporation Members shall be persons, firms, or corporations who promote the objects of THE SOCIETY by the payment of annual dues as provided in the By-Laws. Such Corporation Members shall be entitled to designate a representative to be known as Voter of a Corporation Member.

Article B V (1) (e) Corporation Members shall pay a minimum annual fee of twenty-five dollars ($25.00), four dollars and fifty cents ($4.50) of which shall be a subscription to *The Journal and Ceramic Abstracts*, and one dollar and fifty cents ($1.50) of which shall be a subscription to *The Bulletin*.

Article R III (1) (e) Persons, firms, or corporations may make application for election to the grade of Corporation Member, provided it is endorsed by at least one Member of THE SOCIETY and is accompanied by the payment of dues to the first day of the next succeeding January. If the application is approved by the General Secretary, the applicant is automatically admitted to the grade of Corporation Member.

ROSTER OF PAID CORPORATION MEMBERS

Abbé Engineering Co., New York, N. Y.
Abingdon Sanitary Mfg. Co., Abingdon, Ill.
A C Spark Plug Co., Flint, Mich.
Adamston Flat Glass Co., Clarksburg, W. Va.
Akron Porcelain Co., Akron, Ohio
American Gas Assn., New York, N. Y.
American Glass Corp., Greensburg, Pa.
American Lava Corp., Chattanooga, Tenn.
American Nepheline Corp., Rochester, N. Y.
American Porcelain Enamel Co., Muskegon, Mich.
American Potash & Chemical Corp., New York, N. Y.
American Refractories Institute, Pittsburgh, Pa.
American Rolling Mill Co., Middletown, Ohio
American Stove Company, St. Louis, Mo.
Amsler-Morton Co., Inc., Pittsburgh, Pa.
Anchor Hocking Glass Corp., Lancaster, Ohio
Arketex Ceramic Corp., Brazil, Ind.
Armstrong Cork Co., Lancaster, Pa.
Atlantic Terra Cotta Co., Perth Amboy, N. J.

Babcock & Wilcox Co., New York, N. Y.
Ball Brothers Co., Muncie, Ind.
Baltimore Enamel & Novelty Co., Baltimore, Md.
Bardin, Paul, e Hijos, Soc. Anon. Com., Buenos Aires, Argentina, South America
Bausch & Lomb Optical Co., Rochester, N. Y.
Belden Brick Co., Canton, Ohio
Blue Ridge Glass Corp., Kingsport, Tenn.
Bonnot Company, Canton, Ohio
Braun Corp., Los Angeles, Calif.
Brockway Glass Company, Inc., Brockway, Pa.
Buck Glass Company, Baltimore, Md.
Buffalo Pottery Co., Buffalo, N. Y.

Canadian General Electric Co., Ltd., Peterborough, Ontario, Canada
Canton Stamping & Enameling Co., Canton, Ohio
Carborundum Company, Niagara Falls, N. Y.
Carnegie-Illinois Steel Corp., Pittsburgh, Pa.
Carr-Lowrey Glass Co., Baltimore, Md.
Celo Mines, Inc., Burnsville, N. C.
Central Silica Company, Zanesville, Ohio
Ceramic Color & Chemical Mfg. Co., New Brighton, Pa.
Ceramics Publishing Co., Inc., Newark, N. J.
Certain-Teed Products Corp., Buffalo, N. Y.
Champion Spark Plug Co., Detroit, Mich.
Chattanooga Glass Co., Chattanooga, Tenn.
Chicago Hardware Foundry Co., North Chicago, Ill.
Chicago Pottery Co., Chicago, Ill.
Chicago Vitreous Enamel Product Co., Cicero, Ill.
Clark, N., & Sons, San Francisco, Calif.
Colonial Insulator Co., Akron, Ohio
Commercial Decal Products, Inc., East Liverpool, Ohio
Consolidated Feldspar Corp., Trenton, N. J.
Coors Porcelain Company, Golden, Colo.
Corhart Refractories Co., Inc., Louisville, Ky.
Corning Glass Works, Corning, N. Y.
Crane Enamelware Company, Chattanooga, Tenn.
Crooksville China Co., Crooksville, Ohio
Crossley Machine Co., Trenton, N. J.
Crossman Company, South Amboy, N. J.
Crown Potteries Co., Evansville, Ind.

DeVilbiss Co., Toledo, Ohio
Dixon, Joseph, Crucible Co., Jersey City, N. J.
Drakenfeld, B. F., & Co., New York, N. Y.
Du Pont de Nemours, E. I., & Co., R. & H. Chemicals Dept., Wilmington, Del.

Edgar Plastic Kaolin Co., Metuchen, N. J.
Electric Auto-Lite Co., Fostoria, Ohio
Electro Refractories & Alloys Corp., Buffalo, N. Y.
Empire Sheet & Tin Plate Co., Mansfield, Ohio
Engelhard, Charles, Inc., Newark, N. J.
English China Clays Sales Corp., New York, N. Y.
Eureka Flint & Spar Co., Trenton, N. J.
Exolon Company, Blasdell, N. Y.

Fabrica de Ladrillos Industriales y Refractarios, Monterrey, N. L., Mexico
Fairfacts Company, Inc., Trenton, N. J.
Federal Seaboard Terra Cotta Corp., Perth Amboy, N. J.
Ferro Enamel Corp., Cleveland, Ohio
Ferro Enamels (Australia) Pty. Ltd., Alexandria, N.S.W., Australia
Findlay Clay Products Co., Washington, Pa.
Foote Mineral Co., Philadelphia, Pa.
Fords Porcelain Works, Perth Amboy, N. J.
Fostoria Glass Co., Moundsville, W. Va.
Frazier-Simplex, Inc., Washington, Pa.

Garco Products, Inc., Butler, Pa.
Gayner Glass Works, Salem, N. J.
General Ceramics Co., New York, N. Y.
General Electric Co., Lamp Dept., Pitney Glass Works, Nela Park, Cleveland, Ohio
George, W. S., Pottery Co., East Palestine, Ohio
Gillinder Brothers, Inc., Port Jervis, N. Y.
Gladding, McBean & Co., Lincoln, Placer County, Calif.
Gleason-Tiebout Glass Co., Maspeth, N. Y.
Glenboig Union Fireclay Co., Ltd., Glenboig, Scotland
Great Lakes Foundry Sand Co., Detroit, Mich.
Great Lakes Steel Corp., Detroit, Mich.
Green, A. P., Fire Brick Co., Mexico, Mo.

Haeger Potteries, Inc., Dundee, Ill.
Hall China Company, East Liverpool, Ohio
Hancock Brick & Tile Co., Findlay, Ohio
Hanley Company, Summerville, Pa.
Hanovia Chemical & Mfg. Co., Newark, N. J.
Hardinge Company, Inc., York, Pa.
Harshaw Chemical Co., Cleveland, Ohio
Hartford-Empire Co., Hartford, Conn.
Haws Refractories Company, Johnstown, Pa.
Hazel-Atlas Glass Co., Wheeling, W. Va.
Hommel, O., Co., Pittsburgh, Pa.
Houze, L. J., Convex Glass Co., Point Marion, Pa.
Humphryes Manufacturing Co., Mansfield, Ohio
Hygrade Sylvania Corp., Emporium, Pa.

Illinois Clay Products Co., Joliet, Ill.
Industrial Ceramic Products, Inc., Columbus, Ohio
Ingram-Richardson Mfg. Company of Indiana, Inc., Frankfort, Ind.
International Clay Machinery Co., Dayton, Ohio
International Smelting & Refining Co., Akron, Ohio
Ironton Fire Brick Co., Columbia, S. C.
Isolantite, Incorporated, Belleville, N. J.

Jova Brick Works, Roseton, N. Y.

Kaolin, Incorporated, Spruce Pine, N. C.
Kentucky Clay Mining Co., Mayfield, Ky.
Kentucky-Tennessee Clay Co., Mayfield, Ky.
Knowles, Edwin M., China Co., Newell, W. Va.
Kohler Company, Kohler, Wis.
Koppers Company, Pittsburgh, Pa.
Kraftile Company, Niles, Calif.

Laclede-Christy Clay Products Co., St. Louis, Mo.
Lancaster Iron Works, Lancaster, Pa.
Lapp Insulator Co., Inc., Le Roy, N. Y.
Laughlin, Homer, China Co., Newell, W. Va.
Lava Crucible Co. of Pittsburgh, Pittsburgh, Pa.

Lee Clay Products Company, Clearfield, Ky.
Libbey Glass Company, Toledo, Ohio
Libbey-Owens-Ford Glass Co., Toledo, Ohio
Locke Insulator Corp., Baltimore, Md.
Louthan Manufacturing Co., East Liverpool, Ohio
Lynch, A. J., & Co., Los Angeles, Calif.

Mansfield Sanitary Pottery, Inc., Perrysville, Ohio
Maryland Glass Corp., Baltimore, Md.
Maxson, Elwyn L., Los Angeles, Calif.
McHose, L. H., Inc., Perth Amboy, N. J.
McKee, Arthur G., & Co., Cleveland, Ohio
Metal & Thermit Corp., New York, N. Y.
Metro Glass Bottle Co., Jersey City, N. J.
Mexico Refractories Co., Mexico, Mo.
Mississippi Glass Co., New York, N. Y.
Mitchell Clay Mfg. Co., St. Louis, Mo.
Moore Enameling & Mfg. Co., West Lafayette, Ohio
Moore & Munger, New York, N. Y.
Mosaic Tile Company, Zanesville, Ohio
Mount Clemens Pottery Co., Mount Clemens, Mich.

National Engineering Co., Chicago, Ill.
National Fireproofing Corp., Pittsburgh, Pa.
National Gypsum Co., Clarence Center, N. Y.
National Industrial Sand Assn., Washington, D. C.
National Lead Co., Brooklyn, N. Y.
National Lime and Stone Co., Findlay, Ohio
New Castle Refractories Co., New Castle, Pa.
New Jersey Porcelain Co., Trenton, N. J.
New Jersey Pulverizing Co., New York, N. Y.
Nippon Gaishi Kabushiki Kaisha, Nagoya, Japan
Nippon Toki Kaisha, Ltd., Nagoya, Japan
North American Refractories Co., Cleveland, Ohio
North Carolina Feldspar Corp., Erwin, Tenn.
Norton Company, Worcester, Mass.

Ohio Clay Co., Cleveland, Ohio
Ohio Hydrate & Supply Co., Woodville, Ohio
Ohio Insulator Company Div., Ohio Brass Co., Barberton, Ohio
Old Hickory Clay Co., Paducah, Ky.
Olean Tile Co., Olean, N. Y.
Onondaga Pottery Co., Syracuse, N. Y.
Orefraction, Inc., Pittsburgh, Pa.
Orton, Edward, Jr., Ceramic Foundation, Columbus, Ohio
Owens-Illinois Glass Co., Alton, Ill.
Owens-Illinois Pacific Coast Co., San Francisco, Calif.

Pacific Clay Products, Los Angeles, Calif.
Pacific Coast Borax Co., New York, N. Y.
Pacific Tile & Porcelain Co., Los Angeles, Calif.
Paper Makers Importing Co., Inc., Easton, Pa.
Pass & Seymour, Inc., Solvay, N. Y.
Pennsylvania Pulverizing Co., Lewistown, Pa.
Pennsylvania Salt Mfg. Co., Philadelphia, Pa.
Pfaudler Company, Rochester, N. Y.
Pittsburgh Plate Glass Co., Creighton, Pa.
Porcelain Enamel & Mfg. Co., Baltimore, Md.
Porcelain Products, Inc., Findlay, Ohio
Portsmouth Clay Products Co., Portsmouth, Ohio
Potters Supply Co., East Liverpool, Ohio
Precision Grinding Wheel Co., Philadelphia, Pa.

Quigley Company, Inc., New York, N. Y.

Ramtite Co., Chicago, Ill.
Ransome Concrete Machinery Co., Dunellen, N. J.
Remmey, Richard C., Son Co., Philadelphia, Pa.
Republic Steel Corp., Youngstown, Ohio
Rickman & Rappe, Köln-Kalk, Germany
Riddell, W. A., Co., Bucyrus, Ohio
Roseville Pottery Co., Zanesville, Ohio
Ross-Tacony Crucible Co., Philadelphia, Pa.
Rundle Manufacturing Co., Milwaukee, Wis.
Rustless Iron Co., Ltd., Keighley, England

Safety Grinding Wheel & Machine Co., Springfield, Ohio
San Miguel Brewery, Inc., Manila, P. I.
Schundler, F. E., & Co., Inc., Joliet, Ill.
Seagram, Joseph E., & Sons, Inc., Louisville, Ky.
Shenango Pottery Company, New Castle, Pa.
Simonds Worden White Co., Dayton, Ohio
Smith & Stone, Ltd., Georgetown, Ontario, Canada
Solvay Process Company, Syracuse, N. Y.
Spinks, H. C., Clay Co., Newport, Ky.
Square D Company, Detroit, Mich.
Standard Brick and Tile Corp., Evansville, Ind.
Standard Lime & Stone Co., Baltimore, Md.
Standard Sanitary Mfg. Co., Louisville, Ky.
Star Porcelain Co., Trenton, N. J.
Stark Brick Co., Canton, Ohio
Stauffer Chemical Co., Inc., New York, N. Y.
Steele, J. C., & Sons, Statesville, N. C.
Sterling Grinding Wheel Co., Tiffin, Ohio
Structural Clay Products Institute, Washington, D. C.
Stupakoff Laboratories, Inc., Latrobe, Pa.
Summitville Face Brick Co., Summitville, Ohio
Sur Enamel & Stamping Works, Ltd., Calcutta, India
Surface Combustion Corp., Toledo, Ohio
Swindell Brothers, Baltimore, Md.
Swindell-Dressler Corp., Pittsburgh, Pa.

Taylor, Smith, & Taylor Co., Chester, W. Va.
Texas Mining & Smelting Co., Laredo, Texas
Titanium Alloy Mfg. Co., Niagara Falls, N. Y.
Toyo Toki Kaisha, Kokura City, Japan
Trenton Potteries Co., Trenton, N. J.
Twyfords, Limited, Stoke-on-Trent, England
Tyler, W. S., Company, Cleveland, Ohio

Union Electrical Porcelain Works, Inc., Trenton, N. J.
United Clay Mines Corp., Trenton, N. J.
United Glass Bottle Mfrs., Ltd., London, England
United States Gypsum Co., Chicago, Ill.
Universal Clay Products Co., Sandusky, Ohio
Universal Dental Co., Philadelphia, Pa.
Universal Sanitary Mfg. Co., New Castle, Pa.

Vanderbilt, R. T., Company, New York, N. Y.
Vereeniging Brick & Tile Co., Ltd., Vereeniging, Transvaal, South Africa
Vesuvius Crucible Co., Swissvale, Pa.
Victor Insulators, Inc., Victor, N. Y.
Vitrefrax Corporation, Los Angeles, Calif.
Vitreous Steel Products Co., Cleveland, Ohio
Vitro Manufacturing Co., Pittsburgh, Pa.

Wallace China Co., Ltd., Huntington Park, Calif.
Waltham Grinding Wheel Co., Waltham, Mass.
Washington Porcelain Co., Washington, N. J.
Wayne Laboratories, Waynesboro, Pa.
Western Brick Co., Danville, Ill.
Western Electric Co., Chicago, Ill.
Westinghouse Electric & Mfg. Co., Derry, Pa.
West Virginia Brick Co., Charleston, W. Va.
Wheeling Steel Corp., Yorkville, Ohio
Wisconsin Porcelain Co., Sun Prairie, Wis.

CORPORATION MEMBERSHIPS ARE PROFITABLE INVESTMENTS

METAL & THERMIT CORPORATION BUILDS NEW RESEARCH LABORATORY

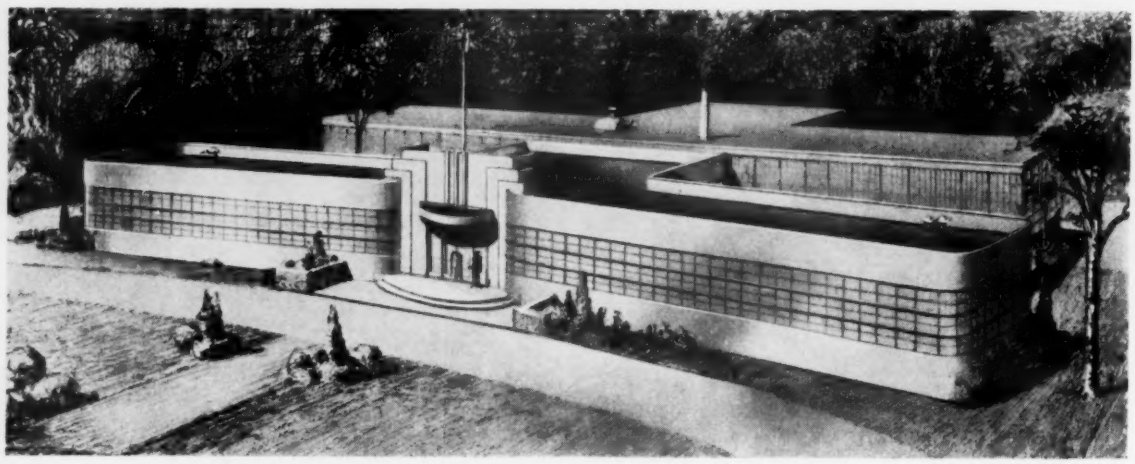
The Metal & Thermit Corporation, 120 Broadway, New York, N. Y., continuing to expand its research and development activities, started the construction of a new research laboratory at Rahway and Randolph Aves., Woodbridge, N. J., on July 1.

The building was designed by architect Carl Preis, 230 Park Ave., N. Y., and is being built by Andrew Christensen & Son, Inc., of Elizabeth, N. J. Occupancy is scheduled for November 15, 1941.

The new laboratory, located on a ten-acre tract of land, is one story high and will have 16,000 sq. ft. of floor space. It is modern in architectural treatment, and there is a continuous line of large windows around the entire structure. Steel, concrete, brick, and hollow tile will provide fireproof construction.

The front section of the building will house administrative offices, a library, and analytical laboratories, as well as the chemical laboratories of the ceramic and detinning departments of the Corporation. Two wings at the rear will be occupied by laboratories devoted to research on arc welding electrodes, thermit welding, and thermit metals and alloys; a third wing will contain process and manufacturing development divisions.

Research activities of the Metal & Thermit Corporation are under the direction of Lincoln T. Work, formerly of Columbia University.



New Research Laboratory of the Metal & Thermit Corporation

NEW YORK STATE COLLEGE OF CERAMICS

Electro Refractories & Alloys Fellowship

L. U. Milward and Grant S. Diamond, president and vice-president, respectively, of the Electro Refractories & Alloys Corporation, Buffalo, N. Y., in 1938 initiated the practice of granting a fellowship to a senior student instead of to a graduate student, as is the usual procedure. A rigid examination is given to the students while they are juniors, and the student making the highest grade is awarded the fellowship.

Robert A. Whitwood, working on the properties of refractories, held the fellowship during 1940–1941. He is now in the regular employment of the Electro Refractories & Alloys Corporation. Paul T. Whelan won the fellowship for 1941–1942, and he will continue the work of Mr. Whitwood.

Student Branch Activities

The Student Branch at the New York State College of Ceramics has had an exceptionally active and enthusiastic year, with an average attendance at the monthly meetings of more than one hundred persons. Speakers at the meetings during the year were G. J. Easter, T. A. Klinefelter, H. M. Kraner, J. L. Carruthers, L. G. Ghering, and S. F. Walton.

The Student Branch also put on the successful St. Patrick's program which M. E. Holmes initiated eight years ago.

The officers elected for 1941–1942 are G. W. Kellogg, *President;* D. L. Armant, *Vice-President;* R. E. Rhodes, *Secretary;* and R. D. Luce, *Treasurer.*

EDWARD ORTON, JR., CERAMIC FOUNDATION FELLOWSHIPS

Five Fellowship appointments have been made by the Edward Orton, Jr., Ceramic Foundation for 1941–1942.

New York State College of Ceramics: MILTON A. TUTTLE, "Effect of Glaze Penetration on Resistance of Porous Bodies to Crazing and Shivering" (Part II).

Ohio State University: J. ALLEN PIERCE, "Flux Constituent of Vitreous Whiteware Bodies" (Part III).

Pennsylvania State College: MELLEN A. KNIGHT, "The System Magnesium Oxide–Boron Oxide."

Rutgers University: WILLIAM F. MCDEVIT, "Effect of Atmosphere on Qualities of Colors Produced in Colored Glazes of Several Types" (Part II).

University of Illinois: HAROLD C. JOHNSON, "Glaze Slip Control" (Part III).

INSTITUTE OF CERAMIC ENGINEERS JOINT MEETING

The Institute of Ceramic Engineers will join in the fall meeting of the Industrial Minerals Division of the A.I.-M.M.E. which is to be held October 23 to 25, 1941, in Rolla, Mo. It is tentatively planned to have three technical sessions and to leave Saturday free for field trips. Max Y. Seaton, United Chemicals, Inc., New York, N. Y., will present a paper during the session which is to be devoted to a discussion of magnesium.

TENTH ANNUAL NATIONAL CERAMIC EXHIBITION

OCTOBER 18–NOVEMBER 12, 1941

The tenth anniversary of the National Ceramic Exhibition will be celebrated by the showing of a special exhibition of Contemporary Ceramic Art of the Western Hemisphere (from the United States, South America, and Canada) at the Syracuse Museum of Fine Arts, Syracuse, N. Y., from October 18 to November 12, 1941. This exhibition, sponsored by the Syracuse Museum of Fine Arts and the International Business Machines Corporation, is the first exhibition of living ceramic art of the Western Hemisphere to be assembled, and it takes the place of the international ceramic exhibition that was pending before the European war began. South American and Canadian pottery will be selected by art authorities from these countries through the cooperation of Thomas J. Watson, president of the International Business Machines Corporation and a noted art patron.

X-RAY ANALYSIS IN INDUSTRY

Cooperation Is Solicited

The following notice appeared in the *Journal of Scientific Instruments*, The University, Reading, Berks, England.

The earliest application of X-ray analysis was made to determine the atomic arrangement in crystalline structures, and this work has had far-reaching results in many branches of science. This powerful tool of the physicist of recent years has been used to investigate many other characteristics of the solid state, such as the identification of crystalline constituents of minute samples, the structure of alloys, the identification of intermediate products in chemical processes, the identification of allotropic changes in refractories, and the determination of submicroscopic crystal size and orientation. A new field, hardly explored at all as yet, is that of the submicroscopic structures within each individual crystal, such as occur in age-hardening and other types of imperfect phase precipitation in the solid state. Such structures profoundly influence physical properties and are therefore of great interest.

The importance of this subject, particularly for the present war effort, has led to a widely expressed desire for closer collaboration and sharing of experience between those concerned with the subject. This desire is being met by the publication of a series of papers invited by Sir Lawrence Bragg, president of the Institute of Physics and a pioneer in this field, and they are being published by the Institute in two special issues of the *Journal of Scientific Instruments* (which Journal is now partly devoted to the applications of physics in industry). These numbers are enlarged to double the normal wartime size. The first group of papers was published in the May issue and dealt with the applications of X-ray methods as applied to a wide range of industrial problems. The second group, which will appear in two or three months, will deal with the technique of the methods and some recent developments.

Copies of these special issues may be obtained from the Institute of Physics (temporary address, The University, Reading) or from any bookseller. The issues are 2*s.* 8*d.* each, post free. Early application for copies is advised owing to the limitation of paper supplies.

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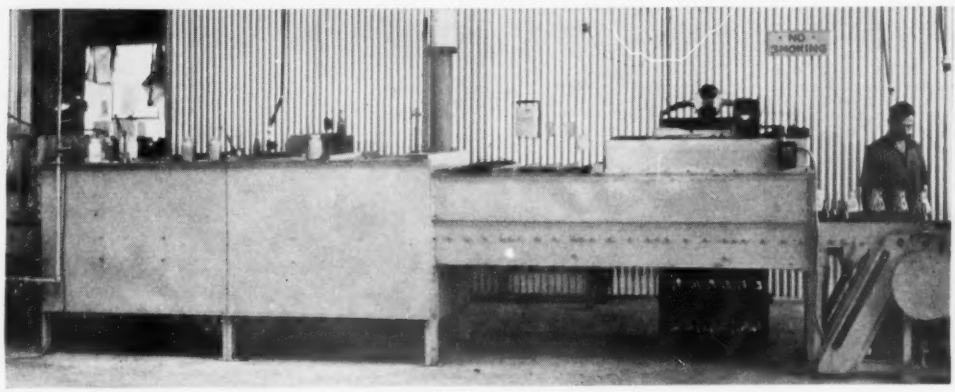

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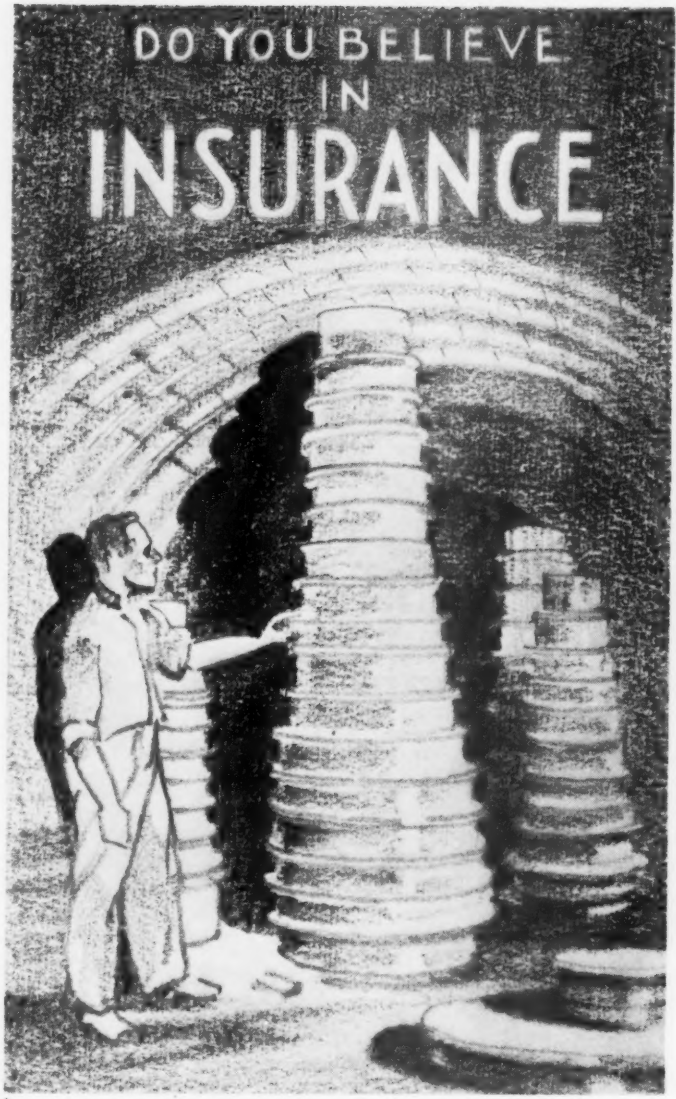

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Harshaw Chemical Co.
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Paper Makers Importing Co.
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THERE it was again—a dark stain on the plate where the fried egg had rested. It wouldn't wash off. Laboratory tests showed that the color—an opaque color for glass—had excellent gloss and fine resistance to acid and alkali. But that egg stain! That problem had to be licked before the color could be offered to the manufacturers.

So back to the research laboratories went the color. Chemists went to work. They couldn't change the egg so they set about changing the stain-resistance of the color. After weeks of work and hundreds of tests with fried eggs they came up with the answer—a glass color which would meet industrial requirements, stand up without discoloration in every-day service.

The approach to the problem and the persistent methods used in its solution are typical of what du Pont research is doing to find the "right answers" to the color problems of the manufacturers of ceramics and glassware. And backing up the research and developments is du Pont Ceramic Service—a staff of experienced technical men —to assist in the use and application of du Pont colors.

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Harshaw Chemical Co.
The Hommel, O., Co., Inc.
The Vitro Mfg. Co.

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The Hommel, O., Co., Inc.

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Norton Co. (*Alundum-Crystolon*)

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Corhart Refractories Co.
Norton Co. (*Crystolon*)

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Norton Co.

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Harshaw Chemical Co.
The Hommel, O., Co., Inc.

Iron Chromite
Harshaw Chemical Co.

Iron (Enameling)
American Rolling Mill Co.

Iron Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
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Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Kaolin
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Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Maxson, Elwyn L.
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Thomas Alabama Kaolin Co.
United Clay Mines Corp.
The Vitro Mfg. Co.

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Denver Fire Clay Co.
Drakenfeld, B. F., & Co.
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Swindell-Dressler Corp.

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Celo Mines, Inc.

Kryolith (see Cryolite)
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Norton Co.

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Carborundum Co.
Electro Refractories & Alloys Corp.

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Frazier-Simplex, Inc.
Swindell-Dressler Corp.

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Lithium Minerals
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Harshaw Chemical Co.
The Hommel, O., Co., Inc.
The Vitro Mfg. Co.

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Foote Mineral Co.
The Hommel, O., Co., Inc.

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Harshaw Chemical Co.
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WILL BE PUBLISHED IN THE OCTOBER BULLETIN

This ROSTER will be the "Who's Who" of Ceramic Technology; therefore, the name of every ceramist should be listed.

Advertising will be especially effective in the October Bulletin because the circulation will be greatly increased and because this Roster will be referred to constantly.

Please write for advertising rates

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Mr. Pete Potter
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Pottsville, U. S. A.

Dear Pete:

If I were you, I would go north on a vacation. We can't get away now. We must fill our sheds for winter while the sun is shining, and boy! it is really beaming down!!

Don't worry about your ball clay while you are fishing. We will ship your cars the day you say, and the quality won't vary while you are away.

Best wishes,

Dick Carothers

General Manager
H. C. SPINKS CLAY COMPANY

RBC:MLN

Determining fineness of Tin Oxide in Metal & Thermit ceramic laboratory.

the agate that wouldn't polish...

A phone call from an agitated manufacturer informed us that his attempts to polish agate with Tin Oxide were a failure. How could we help?

Analysis in our own ceramic laboratory revealed that the "agate" was actually "Brazilian agate" (calcite) and much softer than genuine agate. A softer grade of Tin Oxide, more suited to the purpose, was formulated which polished the Brazilian agate satisfactorily and the manufacturer was able to resume production without further delay.

As manufacturers of Tin Oxide and Sodium Antimonate it is an important part of our service to help firms solve production problems involving their use.

If you are having trouble with your glaze or enamel — or any process in which Tin Oxide or Sodium Antimonate can be used — the facilities of our laboratory are at your disposal. Inquiries are invited.

M&T

TIN OXIDE
SODIUM ANTIMONATE

★

The use of M & T Tin Oxide and Sodium Antimonate by many prominent ceramic manufacturers has established these opacifiers as leaders in the field. Close laboratory control assures a high degree of opacity, uniformity and a pure, brilliant finish.

METAL & THERMIT CORPORATION

120 BROADWAY NEW YORK, N. Y.